FOUNDRY TRADE JOURNAL

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Materials Outlook

The rationing of steel has its repercussions on the foundry industry, as firms short of this material tend to slow down on their orders for castings because the two materials go together for the creation of the products of the engineer. Steel and other materials being in short supply, the users have been asked to set-out their needs on their requisitions. Human nature being what it is, no errors of understatement are likely to have occurred. Thus in the baskets of the Ministry, the requisitions, now subject to greater scrutiny than ever before, tend to pile up. The impact of these conditions is now being felt and will continue for some time, but it would appear that when things have sorted themselves, supplies should be much easier, especially by the third quarter of the year. Much of the paper demand is artificial. The published figures of demand for new cars is quite fictional and on a free market only a limited percentage would be taken up.

It would seem that a parallel situation has developed in America and in what to us is somewhat picturesque language, the Editor of *Materials and Methods* has summarized the conditions in his country in the following paragraph: "A LOT OF BUBBLES SEEM READY TO POP—The Commerce Department says U.S. output has been levelling off, Alex Lewyt denies that consumer appliance shortages are ahead. The N.P.A. [National Price Administration] eased metal restrictions on small users. Among the producers, steel, tin and even copper people are screaming that both the long- and short-term shortages are being magnified by Government scare talk and buying restrictions. It is certain that most plastics are in plentiful supply right now. *This may add up to easier supplies—soon.* Remember the boom-or-bust nature of Government price and supply controls makes an overnight transition from shortage to over supply inescapable. Everyone is fighting for more than they need and as soon as they get it, over supply sets in."

London quite often gets New York weather after a week or ten days interval and what our American colleague has written may well in the near future epitomize national trading conditions here. The better appearance of the pound sterling in overseas markets since the Budget should result in the easing of prices of raw materials. In assessing the future, it would be foolish not to envisage the impact of the increasing production in Germany and Japan. The ironfoundry industry in the western zone of the former country is now working to 87·3 per cent. of capacity. The increased cost of living has undoubtedly slowed-down the purchase of anything other than necessities, and thus the factories making non-essential goods will soon reduce their pressure for supplies of raw material. "This may add up to easier supplies—soon" accompanied, apparently, by much "bubble popping."

E

Honorary Members

At recent meetings of the Council of the Institute of British Foundrymen, two new honorary members were elected in honour of their service to the Institute and to the industry, namely, Col. W. J. Grose, of South Africa, and Mr. Charles W. Bigg, of Derby.

Col. W. J. Grose was one of the founder members of the South African branch, having joined in April, 1938. He was elected president of the branch in 1946. Col. Grose was originally a patternmaker and was associated with the industry in South Africa for many years. One of his great activities has been the training of pattern-maker apprentices. He had a distinguished career in the first world war and lost one of his limbs; this, however, did not prevent him from doing active military work in the second world war.

Mr. Charles W. Bigg is a native of Luton, Bedfordshire, but has spent practically all his business life in Derby. He joined the Institute in 1915; in due course became president of the East Midlands branch, and in the year 1937-38 he was president of the Institute, and from 1944 until 1951, honorary treasurer. Mr. Bigg has taken a close interest in almost every branch of the Institute's activities and has done a great deal of personal work in many directions. He has also taken part in industrial and administrative activities connected with the ironfoundry industry and was the first director for iron castings in the Iron and Steel Control at the outbreak of the last war. Although Mr. Bigg relinquished the honorary treasurership in 1951, he continues to take an active part in the work of the Institute.

Textile Plant Exhibition

Heaton & Flint, spindle flyer makers, Textile Works, Parkwood Street, Keighley, have taken over premises at Cullingworth, near Keighley, known at High Mills, and recently used for growing mushrooms, with the intention of establishing there a showroom to boost their products for export. The premises comprise a large and a small mill, with a total area of about 15,000 sq. ft., and it is hoped to instal a complete plant with all spare accessories and motors so as to allow prospective buyers to see the machinery actually running. The firm is concerned with the re-conditioning of textile machinery, and also the manufacture of new spare parts. There is, in addition, an extensive foundry used formerly for the production of textile machinery parts, but now devoted to the production of machine-tool castings in connection with the rearmament drive. The firm is seeking to extend its already considerable overseas trade, and for the purpose of establishing new connections, Mr. Sam Heaton, managing director of the firm, is at present on a five-month sales tour in India, and at the end of the month he leaves for Australia.

THE WEEKLY AVERAGE of steel production in Sheffield during February was 45,900 tons, an increase of 1,500 tons over the January figure. This, however, was still an average of 1,000 tons a week under the figure for last year.

J. E. STONE & COMPANY, LIMITED, P.O. Box 395, Salisbury, Southern Rhodesia, are anxious to secure agencies for U.K. manufacturers of electric power transformers, steam turbo- and Diesel alternators, E.H.T. and L.T. switchgear, electric motors, electric cable, etc. Interested manufacturers should write to the Company at the above address giving particulars of their products, at the same time notifying the Board of Trade, Commercial Relations and Exports Department, Horse Guards Avenue, London, S.W.1 (reference, CRE/8119/52), of any action taken.

Iron and Steel Institute

The Council of the Iron and Steel Institute announce that the following Medals and Prizes will be presented at the annual general meeting during the morning session on April 30:—

Bessemer Medal.—To Mr. H. H. Burton, C.B.E. (English Steel Corporation, Limited) for his distinguished services to the steel industry and to metallurgy, with particular reference to the development of alloy steels and heavy forgings.

Sir Robert Hadfield Medal.—To Dr. L. Reeve (Appleby-Frodingham Steel Company) in recognition of his contributions to the science and practice of ferrous metallurgy and, in particular, his researches on the weldability of low-alloy steels.

Williams Prize.—Jointly to Mr. J. A. Bond (Appleby-Frodingham Steel Company) and Mr. T. Sanderson (Workington Iron & Steel Company) for their paper on "Full-scale Blast-furnace Trials."

The following changes on the Council of the Institute are also announced:—Mr. W. B. Baxter, O.B.E. (formerly a director of the United Steel Companies, Limited) to be an hon. vice-president; Sir Charles Bruce-Gardner, Bt. (chairman of John Lysaght, Limited) to be a vice-president; Mr. E. Julian Pode (managing director of the Steel Company of Wales, Limited) to become a member of Council.

Foundry Technology for Southampton

By courtesy of the management of John I. Thornycroft Limited, a meeting of local foundrymen was held under the aegis of the London branch of the Institute of British Foundrymen. It was organized by Dr. Einerl foundry manager of the Thornycroft foundries with the help of a local committee and Mr. W. G. Mochrie, the honorary secretary of the London branch. Mr. L. G. Beresford presided over a meeting of about 50 people, which included several members of the London branch Council. The meeting was opened by the showing of a recruitment film on bronze and brass founding by Mr. F. Hudson. This was followed by an informal address by Mr. V. C. Faulkner, a past-president of the Institute, on the advantages of membership. After this, a show of hands indicated that a high percentage of the audience were in favour of establishing a local section to which they would lend their support. After the chairman had thanked Dr. Einerl, Mr. Anderson and others who had been actively associated with him, a second film, kindly loaned by the Council of Ironfoundry Associations, was shown. The principal of the Southampton Technical College promised practical support to the endeavours which were being made.

I.B.F. Golf Meeting

The annual golf tournament of the Institute of British Foundrymen will be held at Woodhall Spa on September 27 and 28. Entry forms will be available shortly. Members of the I.B.F. Golfing Society are reminded that their 1952 subscriptions of 5s. per head are now due and should be sent to the hon. golf secretary, F. Arnold Wilson, William Jacks & Company, Limited, Winchester House, Old Broad Street, London, E.C.2.

Latest Foundry Statistics

According to the British Bureau of Non-ferrous Metal Statistics, the production of copper-base castings in January was 6,195 tons as compared with 5,951 tons in January, 1951.

I.B.F. Conference at Buxton and Sheffield

The forty-ninth annual conference of the Institute of British Foundrymen will be held at Buxton from June 10 to 13, inclusive. This conference is organized by the Sheffield and district branch of the Institute and Dr. C. J. Dadswell, a past-president of that branch, will be installed in the office of president of the Institute during the conference. As hotel accommodation in the city of Sheffield is very crowded in the middle of the week, the Sheffield branch has decided to hold its conference in Buxton, which has ample facilities for meetings, social functions and private hotel accommodation. Sheffield has an intimate association with the conference, however, which will be indicated particularly on the closing day, Friday, June 13, when the whole of the functions, including works visits, luncheon, etc., will be held in Sheffield. Members and ladies will return to Buxton for the final dinner-dance in the evening. Buxton proved to be a most popular rendezvous for the conference in 1950, and it is hoped it will be equally popular this year, not only on account of the facilities it provides, but because of the additional interest offered by the special day at Sheffield. The conference office will be established on Tuesday, June 10, at the Spa Hotel, Buxton. Communications prior to this date should be addressed to the Institute's head office, St. John Street Chambers, Deansgate, Manchester, 3.

Programme*

Tuesday, June 10

Afternoon: Council and committee meetings at the Palace Hotel, open to council and committee members only, who will receive particulars later. Members and ladies make their own arrangements for luncheon and dinner at their hotels.

8.15 p.m. to 11.30 p.m.: Reception and dance by invitation of His Worship the Mayor of Buxton and the Mayoress at the Pavilion (entrance, St. John's Road); welcome by His Worship the Mayor (evening dress optional).

Wednesday, June 11

9.15 a.m.: Annual general meeting in the Ballroom of the Spa Hotel, Buxton (members only). Presentation of awards.

11 a.m.: Presidential address by C. J. Dadswell, Ph.D.(Eng.), *Ingénieur E.S.E.*, M.I.Mech.E.

11.30 a.m.: Edward Williams Lecture, "Fuel and Metal," to be delivered by Prof. R. J. Sarjant, O.B.E., D.Sc., Professor of Fuel Technology, University of Sheffield.

12.30 for 1 p.m.: Luncheon at the Palace Hotel (members and ladies).

2.30 p.m.: Technical sessions at the Spa Hotel.

5 p.m.: Conference adjourns for buffet tea (by invitation).

7 p.m.: Reception by the president and Mrs. Dadswell at the Palace Hotel, prior to the annual banquet.

7.30 p.m. to 1 a.m.: Annual banquet at the Palace Hotel, followed by dancing (evening dress and decorations).

Thursday, June 12

9.30 a.m.: Technical sessions at the Spa Hotel.

12.30 p.m. for 1 p.m.: Luncheon at the Palace Hotel.

2.30 p.m.: Technical sessions at the Spa Hotel.

5 p.m.: Conference adjourns for buffet tea by invitation. Members and ladies make their own arrangements for dinner and are requested to give notice to their hotels of their intention to dine at their hotels.

7.45 p.m.: (*a*) Visit to Buxton Repertory Theatre (members and ladies), or 8.30 p.m. (*b*) film entertainment at the Palace Hotel. At 10 p.m. both parties join at Palace Hotel for light refreshment.

Friday, June 13

Members may select one only of the following visits and one only of the afternoon visits:—*Morning Visits*: Depart by motor-coach from Water Street (near the Opera House), Buxton.

8.45 a.m.: (1) Sheepbridge Equipment, Limited, Chesterfield (alloy iron mechanized foundry).

8.50 a.m.: (2) David Brown Foundries Company, Penistone (non-ferrous and general steel foundries, including centrifugal casting and cement-sand moulding).

9 a.m.: (3) Hadfields, Limited, East Hecla Works, Sheffield (large steel foundries producing all types of steel and manganese-steel castings).

At the conclusion of the morning visits all parties will proceed by motor-coach to the City Hall, Sheffield.

10.15 a.m.: (4) Members who do not wish to participate in one of the morning visits may travel from Buxton to Sheffield Town Hall with the ladies' party at 10.15 a.m. and inspect the civic plate, joining the other members for luncheon and the afternoon visit.

12.30 p.m. for 12.45 p.m.: Luncheon at the City Hall, Sheffield; welcome by the Lord Mayor and Lady Mayoress (by kind invitation of the Sheffield and district branch).

Afternoon Visits: Depart by motor-coach from the City Hall, Sheffield, as follows:—

2 p.m.: (5) Newton Chambers & Company, Limited, Chapeltown (large jobbing foundries, dealing with both heavy and light castings for industrial plant, repetition foundries for castings for cooking, heating and domestic appliances).

2.10 p.m.: (6) Brightside Foundry & Engineering Company, Limited, Ecclesfield (iron foundries for general engineering castings, including rolling-mill castings and a mechanized foundry for the production of ingot moulds).

2.10 p.m.: (7) Edgar Allen & Company, Limited, Imperial Steel Works, Sheffield (general engineering steel castings, manganese-steel castings, etc.) (It is hoped to show an oxygen boil on the Héroult furnace.)

2.20 p.m.: (8) English Steel Corporation, Limited, River Don Works, Sheffield (large steel foundries producing very heavy steel castings; also mechanized foundries for the production of repetition castings).

2.20 p.m.: (9) Osborn Foundries, Limited, Sheffield (varied types of steel castings up to 10 tons in weight; mechanized foundries for repetition castings, including manganese and stainless steel). At the conclusion of the works visits, coaches will proceed direct to Buxton, arriving about 6 p.m., except the coaches from visit (5), which will arrive about 6.30 p.m.

7.30 p.m. for 8 p.m. to 1 a.m.: Dinner/dance at the Palace Hotel, Buxton (evening dress optional).

Ladies' Programme

Tuesday, June 10

4 p.m.: Afternoon tea at the Palace Hotel by invitation of Mrs. Colin Gresty.

8.15 p.m. to 11.30 p.m.: Reception by His Worship the Mayor of Buxton and the Mayoress at the Pavilion (evening dress optional).

Wednesday, June 11

11 a.m.: Cookery demonstration by the North Western Gas Board in the Town Hall, Buxton. Refreshments by kind invitation of the Board.

* Times and detailed arrangements are subject to revision. Final arrangements will be shown in the Conference Handbook which will be sent to all members and ladies participating.

I.B.F. Conference at Buxton and Sheffield

12.45 p.m. for 1 p.m.: Luncheon at the Palace Hotel. Afternoon free.

7 p.m.: Reception at the Palace Hotel by the president and Mrs. Dadswell, prior to the annual banquet.

7.30 p.m. to 1 a.m.: Annual banquet at the Palace Hotel, followed by dancing (evening dress, decorations).

Thursday, June 12

10.30 a.m.: Excursion into Derbyshire. Depart from Water Street (near the Opera House), Buxton, for Haddon Hall. 1 p.m., luncheon at Maynard Arms Hotel, Grindleford; continue at 2.15 p.m., *via* Matlock, Wirksworth and Ashbourne; tea at New Inn, Alsop-en-le-Dale; arrive back at Buxton about 5.30 p.m.

7.45 p.m.: (*a*) Buxton Repertory Theatre, or 8.30 p.m. (*b*) film entertainment at the Palace Hotel (both as for main programme).

10 p.m. (approx.): Refreshments at Palace Hotel.

Friday, June 13

10.15 a.m.: Depart by motor-coach from Water Street, Buxton, for Sheffield.

11.30 a.m.: Visit Town Hall, Sheffield, by invitation of the Lord Mayor of Sheffield (Ald. Peter Buchanan, J.P.); the civic plate will be on view and morning coffee will be served.

12.30 p.m. for 12.45 p.m.: Luncheon, City Hall, Sheffield. Welcome by the Lord Mayor and Lady Mayoress of Sheffield.

2.30 p.m.: Depart from City Hall by motor-coach for Whirlow Brook Park; fashion parade (display of millinery); tea; return direct to Buxton by coach, arriving about 6 p.m.

7.30 p.m. for 8 p.m. to 1 a.m.: Dinner/dance at the Palace Hotel, Buxton (evening dress optional).

Technical Papers

Wednesday, June 11

2.30 p.m.: Session A: Ballroom, Spa Hotel:—No. 1025, "Rôle of the Research Foundry Unit," by G. A. Lillieqvist (American exchange paper), and No. 1026, Report of Sub-committee T.S.35—"Flow of Metal" (film and report).

Thursday, June 12

9.30 a.m. to 12.30 p.m.: Three simultaneous sessions.

Session B: Ballroom, Spa Hotel: No. 1027, "Strength, Structure and Composition of Unalloyed Grey Irons," by H. T. Angus, Ph.D., M.Sc. (member); No. 1028, "Production of Large Ingot Moulds from the Sandslinger in a Mechanized Foundry," by J. Raymond Jones (member), and No. 1029, "Methods Employed in the Production of Heavy Iron Castings," by J. Richardson (member) and C. F. Lawson (member).

Session C: Drawing room, Spa Hotel: No. 1030, "Manufacture of High-quality Steel Castings at a Competitive Price," by J. J. Dewez (Belgian exchange paper); No. 1031, "Probable Trends in British Steelfoundry Practice," by F. Cousans, F.I.M. (member), and No. 1032, "Production of Manganese-steel Castings," by F. Cousans, F.I.M. (member), and W. C. Meredith, M.B.E. (member).

Session D: Coffee room, Spa Hotel: No. 1033, "Sandcast Beryllium Bronze," by Louis Grand (French exchange paper); No. 1034, "Gas Removal from Molten Aluminium Alloys," by A. W. Brace, A.I.M. (associate member), and No. 1035, "Grain Refinement of Non-ferrous Castings," by G. Swinyard, M.Sc., A.I.M. (associate member).

2.30 p.m. to 5 p.m.: Three simultaneous sessions.

Session E: Ballroom, Spa Hotel: No. 1036, "Some Effects of Magnesium on the Formation of Graphite in a Solidifying Cast Iron," by I. C. H. Hughes, B.Sc (associate member), and No. 1037, Report of Sub-committee T.S.32, "Internal Stress in Castings."

Session F: Drawing room, Spa Hotel: No. 1038, "Research on Atmospheric Dust in Foundries, with Special Reference to the Use of Statistical Surveys," by G. M. Michie, M.A., A.Inst.P., A.I.M., and G. H. Jowett, B.A., F.S.S., and No. 1039, "Thermal Expansion and Contraction of Compacted Steelfounding Sands and Mould-washes," by D. V. Atterton, M.A., Ph.D.

Session G: Coffee room, Spa Hotel: No. 1040, "Gamma Radiography in the Foundry," by R. J. Hart (associate member), and No. 1041, "Recent Experience with Basic and Acid Electric Steel," by L. W. Sanders, A.I.M. (associate member).

The last date for receiving conference reply forms is May 17. Members and guests are requested to apply direct to hotels for accommodation and to do so before April 25. Information about available hotels can be obtained from the secretary.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

SCOPE FOR CO-OPERATIVE ACTION

To the Editor of the FOUNDRY TRADE JOURNAL

SIR,—I do not know whether I read the above editorial in the February 21 issue aright but the statement is made as follows:

> "Some experiments, personally carried out many years ago, having for their object the production of refined iron by the melting of turnings in the electric furnace, were a failure, owing to the extreme length of the melting-down period and the consequent high current consumption."

The use of cast-iron borings in direct-arc furnaces has been in vogue in this country for many years. I have in mind one stove-plate foundry in Canada that has operated on 100 per cent. grey iron borings charges since 1926. The fact of the matter is that some years back grey-iron borings were a very cheap form of scrap; however, their usage in the direct-arc furnace has resulted in their being in short supply, at least here in the States. I feel quite sure that a number of the foundrymen in England are making use of 100 per cent. borings charges in making grey iron in the direct-arc furnace. Certainly Birlec Limited at Birmingham have complete knowledge of the practice.

I was much interested in the further statement . . .

> "This was due, we thought, to the formation of refractory graphite walls surrounding the 'tunnels' made by the descending electrodes."

. . . for the reason that about 34 yrs ago the writer came to about the same conclusion in experiments on using grey-iron borings in the direct-arc furnace. In fact, we felt that it was impossible to get production from that source of supply and recommended at that time the use of rotating furnaces as being the only feasible means of handling grey-iron borings or turnings. I cannot help but believe that the foundries using modern arc furnaces in England have since found that grey-iron borings are a very nice charge for the direct-arc furnace.—Yours, etc.

W. B. WALLIS.

P.O. Box No. 1766,
Pittsburgh, Pa., U.S.A.

[The personal experiments which were referred to were carried out just about 35 yrs ago also.—*Editor.*]

Experiences with the Investment Casting Process*

By D. F. B. Tedds, F.I.M.

After first very briefly discussing the possibilities and limitations of the process, the Author next gives in detail examples of special components for which it has been adapted on an experimental basis. In the latter part, various features of investment casting are taken severally and the existing state of the art and lines for future development are treated at some length.

Introduction

The year 1942-43 saw the introduction of the lost-wax or investment casting process into industry in this country and during the intervening years it has had a chequered history. This has been due mainly to two reasons:—(1) The process is intricate both from the technical and production view-points and as such, much secrecy has surrounded it which has hindered rather than helped its development, and (2) although steel castings can be made with a good surface finish, the accuracy attainable on such castings has been highly exaggerated and the process was "over-sold" in its early stages which did irreparable harm.

The past few years have seen a more sobering attitude adopted by the engineer, so that the process is finding its own applications and possibilities and thus proving itself an asset to the designer and an important section of the foundry industry. During this "proving" period, many components have been attempted, some suited and others unsuited to the process, in an effort to find possibilities and limitations. In this Paper, it is proposed first to discuss a few of the more ambitious undertakings, mostly of a development nature, in the hope that they will be of interest to those engaged in the industry and point the way for the engineer. The second part of the Paper deals with some of the more salient points of the process as related to production requirements.

* Paper read before the Birmingham branch of the Institute of British Foundrymen.

DEVELOPMENT APPLICATIONS

Burner Stems

Burner stems (Fig. 1) are used on a turbine engine for delivering the fuel into the flame tubes or combustion chamber and it is necessary for them to be produced with two holes, one $\frac{3}{16}$ in. int. dia. and the other $\frac{1}{8}$ in. int. dia., running parallel from the base flange to the end of the stem. A wooden model of the stem was made, and from it, a soft-metal die was produced in the conventional manner (Fig. 2). Location slots were formed in the die in order to allow stainless steel tubes (wall-section 0.032 in.) to be positioned and wax was injected around them on a vertical-type injection machine. It will be noted that large knurled-steel inserts were attached to the steel tubes, coinciding with the bosses located under the base flange. These minimized the problem of shrinkage cavitation both in the wax and the resultant casting.

Wax runners and feeders were attached to the pattern and connecting tubes were fitted to the pipes as shown in Fig. 3. The complete assembly was then spray-coated with a primary investment and the unit next moulded in the conventional manner, utilizing a pneumatic vibrating table, and sillimanite sand as the secondary investment, bonded with ethyl silicate. The mould when completed was treated in a low-temperature oven for 6 hr. at 45 deg. C. followed by 6 hr. at 120 deg. C., which hardened it and melted-out the wax pattern.

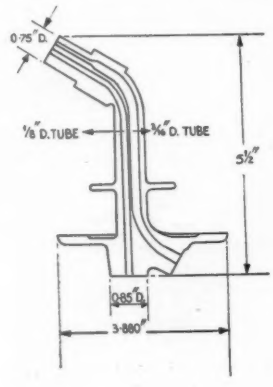
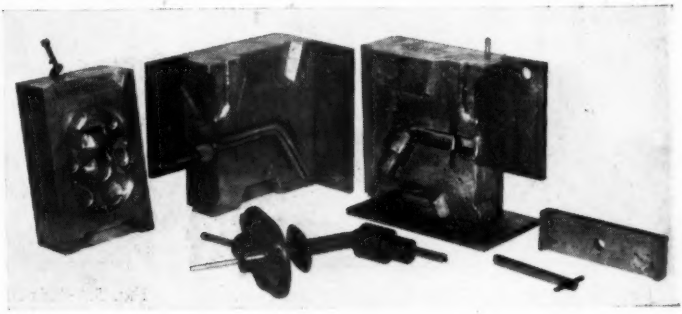


FIG. 1 (LEFT).—*Diagram of Burner Stem used on a Turbine Engine.*

FIG. 2 (BELOW).—*Burner-stem Die and (foreground) one of the Wax Patterns prepared from it.*



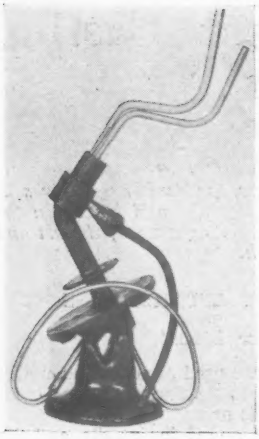


FIG. 3.—*Wax Assembly for the Burner Stem, with Connecting Tubes in position.*

Firing and Casting

The mould was next transferred to the high-temperature firing oven, heated slowly over a period of 5 hr. up to 1,000 deg. C. in order to remove all residual wax etc., and then slowly cooled to approximately 100 deg. C., when it was ready for casting. The metal, previously melted in an indirect-arc furnace, was super-heated to a casting temperature of 1,420 deg. C., and the mould then placed on the furnace. An air attachment was fitted to the tubes protruding from the mould (Fig. 4) and compressed air at 7 lb. per sq. in. pressure was then delivered through these tubes. The mould was clamped firmly on the furnace and the whole unit was inverted through 180 deg., the molten metal being forced into the mould at this pressure of 7 lb. per sq. in. After cooling to room temperature, the casting was removed from the mould, the runner was removed, it was shot-blasted etc., and the unit finally was completed for the engine (Fig. 5).

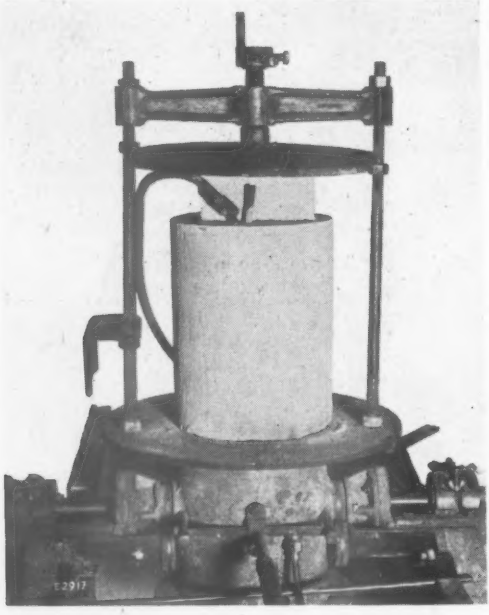


FIG. 4.—*Burner-stem Mould, with Air Attachment, ready for Casting.*

Pitôt Combs

Another component, produced in a similar manner to the burner stems are pitôt combs or tubes used during turbine-engine development in order to measure rate of gas-flow and the pressure distribution in the compressor unit. The range of combs made is shown in Fig. 6.

The stainless-steel tubes used as the inserts in the combs were 0.095 in. dia. with a wall thickness of 0.012 in. and these were located in the soft-metal die (Fig. 7) and the ends were allowed to protrude, thus forming "key points" in the refractory mould when the wax-assembly was moulded. The passage of air through these tubes during the casting operation was considered to be unnecessary since the rate of chilling of the molten metal was greater in this instance (when compared with the burner stems) due to the smaller cross-sectional area of the casting. Because of the absence of air pressure, the ends of the steel tubes were closed in order to exclude the mould mixture from the bores during the moulding operation. The moulds were dried and fired at 1,000 deg. C. in the usual manner and allowed to cool slowly to room temperature prior to the introduction of the molten metal. Finally, the excess length of tube protruding from the casting was removed and the necessary attachments were made in order to complete the assembly (Fig. 8).

Flame-Tubes or Combustion Chambers

Flame-tubes or burners for turbine engines are usually fabricated from sheet material in a heat-resisting alloy *e.g.*, Nimonic 75, but it was decided

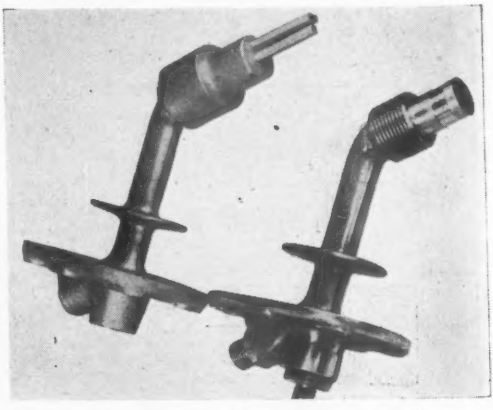
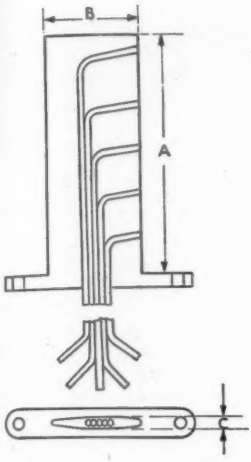


FIG. 5.—*"As-cast" (left) and Finished Burner Stem made by the Investment Process.*



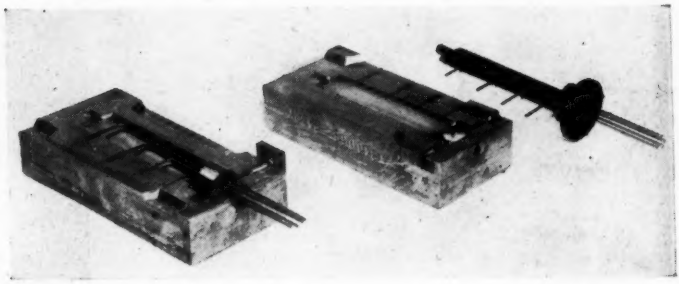


FIG. 7.—*Soft Metal Die with Pitôt Tubes in Position, and a Wax Pattern (R.H.S.).*

FIG. 6 (LEFT).—*Arrangement and Sizes of Pitôt Combs. Dimension Range: A, 10, 6, and 4 in.; B, 2¼, 1, and 1½ in.; and C, 0.25, 0.26 and 0.235 in. respectively.*

to investigate the possibility of casting them by the lost-wax process as an alternative means of production. The first design chosen for the investigation is shown in Fig. 9, the overall length of the component being 14 ft. 5 in., the largest outside diameter 6.75 in. and a general wall thickness 0.060 in.

In order to produce the complete wax assembly it was necessary to divide the component into five sections (Fig. 10), the die for each section being machined from magnesium alloy so that patterns of even section were produced, the die weight being kept to a minimum. The individual wax patterns were assembled into unit formation by normal wax-welding methods. During the initial stages of development, only the nozzle-end of the flame-tube was cast, each further section of the body being added progressively in subsequent tests. It soon became evident that coring of the mould would have to be carried-out, since hot-tearing developed in close proximity to the junction of the inner and outer sections at the nozzle end. Thus a wax core was made incorporating four ingates, to which the pattern was attached, after previously receiving its application of the primary coating on the inner surface (Fig. 11). This coating was then applied to the outer surface (Fig. 12).

When the coating had dried, the pattern was moulded in a special moulding box 10 in. dia. by 24 in. high on a pneumatic vibrator (Fig. 13). The mould was then dried and the wax was removed in the low-temperature oven as previously outlined. A sectioned mould (Fig. 14) clearly shows this. A refractory plug was then cast into the end of the core (Fig. 15) in order to complete the runner and divert the metal, during casting, through the ingates.

The flame tubes were cast in Nimonic 75 material,

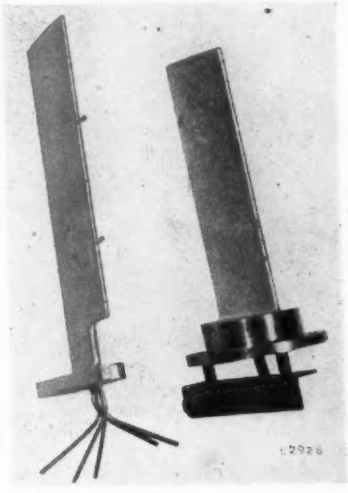


FIG. 8.—*"As-cast" Pitôt Comb (left) and one with Fitted Attachments.*

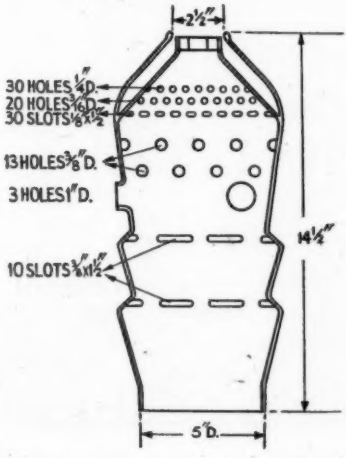


FIG. 9.—*Design of Flame-tube or Combustion Chamber.*

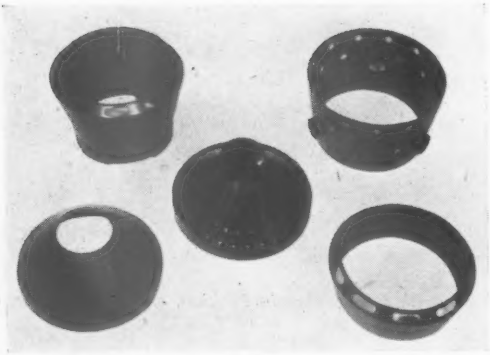


FIG. 10.—*Component Wax Patterns for the Flame-tube Castings.*

which was melted in an indirect-arc furnace of 15 lb. capacity (Fig. 16) poured at a temperature of 1,500 to 1,520 deg. C., and an air pressure of 10 to 12 lb. per sq. in. applied as the furnace was inverted (Fig. 17). Subsequently, moulds were made incorporating an outside metal shroud of 20-gauge Nimonic 75 sheet material, which gave added strength and support to the moulds and minimized mould cracking, the latter being evident in the form of flash lines on the casting shown in Fig. 18. A

FIG. 12.—*Wax Pattern Assembly after spraying ready for Investment.*

FIG. 11.—*Wax Assembly for the Flame Tube being placed over the Wax Core.*

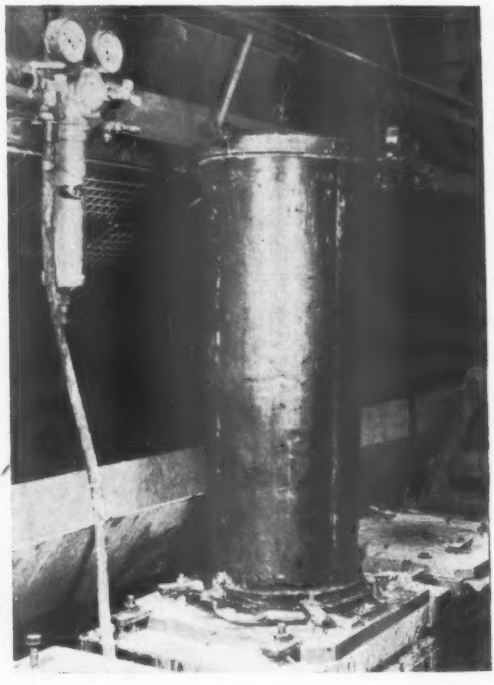


FIG. 13.—*Moulding Arrangement for the Flame Tube Investment Casting.*

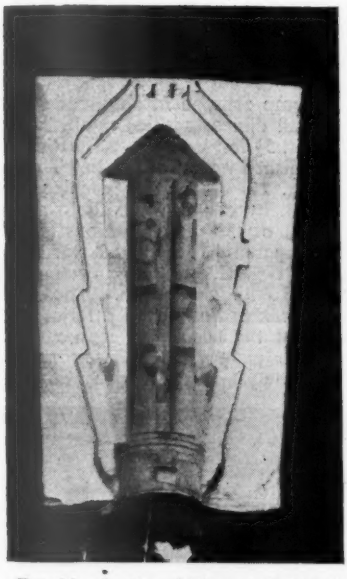


FIG. 14.—*Sectioned Flame-tube Mould after Removal of the Wax.*

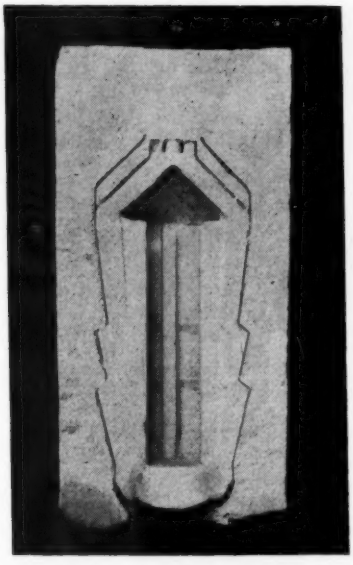


FIG. 15.—*Sectioned Mould with Refractory Plug in position at the Base of the Cored Hole.*

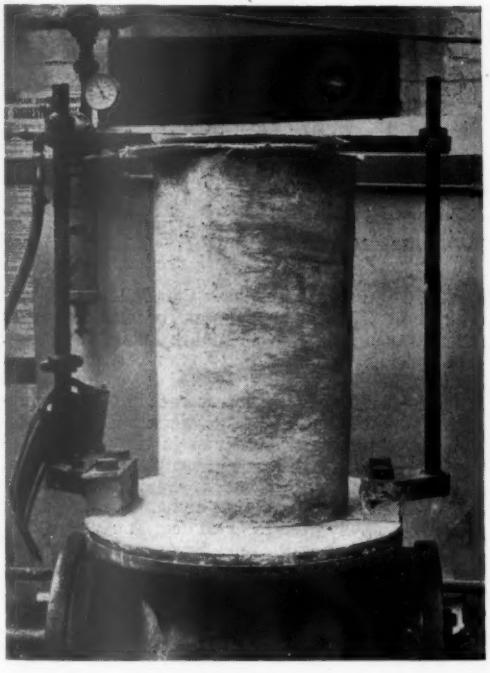


FIG. 16.—*Flame-tube Mould assembled on the Furnace Body ready for Casting.*

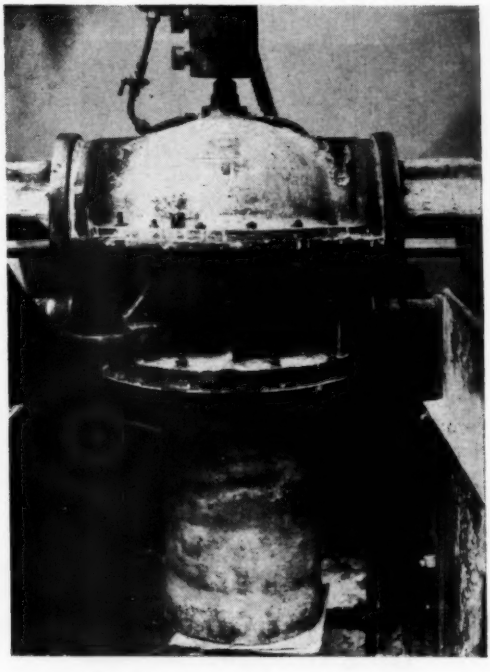


FIG. 17.—*Mould cast by Inverting the Furnace through* 180 *deg.*

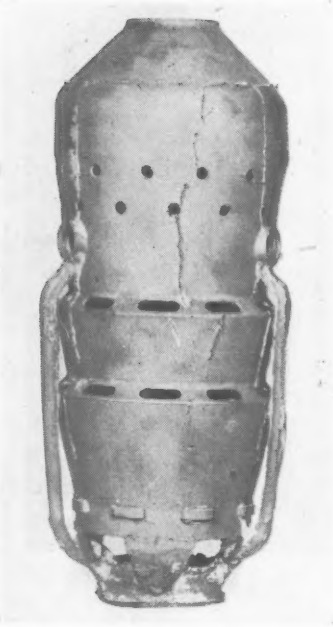


FIG. 18.—*Flame-tube Casting showing "Flash Lines."*

FIG. 19.—*Finished Flame-tube Casting.*

completed casting is shown in Fig. 19 and further designs of flame tubes which were attempted are shown in Fig. 20.

Oil Sump

The oil sump component next made had the following overall dimensions:—Length, 20 in.; width, 12 in.; height, 5½ in.; general wall section, 0.100 in., and had a finished weight of 16½ lb. The wax injection die (Fig. 21) for it was machined from aluminium stock by conventional tool-room methods and consisted of ten major sections (Fig. 22) To produce the pattern necessitated warming the die to 35 to 40 deg. C. prior to injecting wax at a pressure of 70 lb. per sq. in. These conditions allowed the wax to flow to all parts of the die and also permitted the successful dismantling without fracturing the pattern. The wax runners were poured separately and attached by normal joining

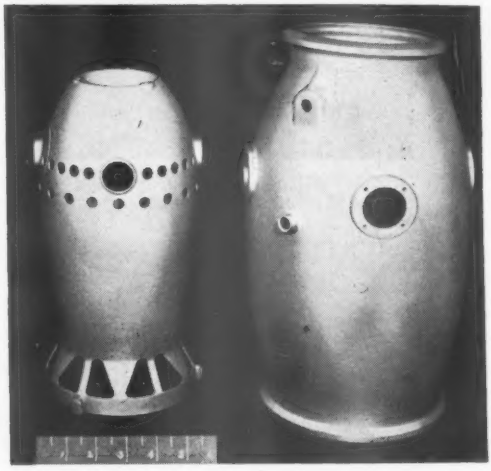


FIG. 20.—*Further Designs of Flame Tubes made by the Investment Process.*

methods. From Figs. 23, 24 and 25, it will be noticed that all heavy sections, bosses, etc., were fed in an effort to combat metal shrinkage cavitation.

A special steel moulding-box, measuring 24 in. long by 17 in. wide by 12 in. high was made and the moulding of such a heavy mould (4 cwt.) presented a major problem. This was successfully overcome by attaching two pneumatic vibrators in tandem and fixing a large surface plate in position. After moulding, the assembly was dried for 24 hr. at 130 deg. C.; the moulding box was removed and the mould slowly fired to 1,000 deg. C. over a period of 8 hr. in a batch-type oven. Exactly 50 lb. of metal to H.R. Crown Max specification was melted in a specially-designed indirect-arc furnace; the mould was clamped in position (Fig. 26) and the metal introduced at 1,520 to 1,540 deg. C. by inverting the furnace through 180 deg. and using an air pressure of 7 to 9 lb. per sq. in. (Fig. 27). Fig. 28 shows the sump as removed from the mould and after shot-blasting.

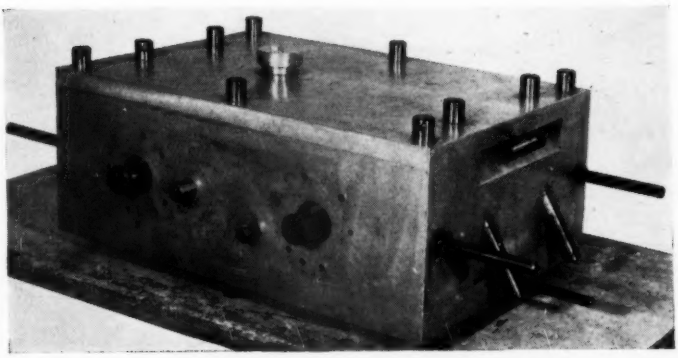


FIG. 21.—*Die for Producing an Oil-sump Pattern for the Investment Process.*

Entry Duct

The entry-duct component, 30 in. dia., with a general wall-thickness of 0.080 in. and a finished weight of 53 lb., consisted of eight pipe-sections and had been previously fabricated from sheet material and joined by welding across the trough of each pipe-section. To produce this by the lost-wax process necessitated making the wax pattern along similar lines, the wax half-sections for the pipes being produced from low-melting-point metal dies and then wax-welded together (Fig. 29). The wax runner for the complete unit was gravity poured into a machined aluminium die (Fig. 30) and located on the base-plate, prior to assembling the eight wax sections. The wax pipes were then fixed in position, using an assembly jig which located each section to its neighbour and also assured, by means of a cylindrical plug-gauge, that the section was at the correct angle (Figs. 31 and 32). After assembly, the wax pattern was coated by spraying with the standard primary coating and when dry, the moulding box, previously waxed inside and also containing a metal shroud, was placed in position ready for moulding.

Handling the Large Mould

The moulding box, made in cast iron, incorporated metal lugs in order to accommodate special lifting equipment. When produced, the mould (3 ft. dia. by 16 in. high and weighing 12½ cwt.) was allowed to remain at room temperature for 15 hr. in order to ensure complete formation of the gel and then was transferred to a low-temperature drying oven for 48 hr. where the wax melted out and the mould partially dried. On removing from the drying oven, the mould was lifted on to its firing bogey and the moulding box was pressed off (Fig. 33), this resting at the base of the bogey during the mould-firing operation. The mould was slowly heated over a period of 24 hr. up to 1,000 deg. C., all alcohol and wax being removed. The bogey and mould were then removed from the firing oven, the moulding box was raised into position round the mould and the whole unit lifted on to the casting furnace (Fig. 34). The molten metal (84 lb. in weight) was then poured into the mould by inverting the indirect-arc furnace through 180 deg., utilizing a casting temperature of 1,520 to 1,540 deg. C. and an air pressure of 8 lb. per sq. in. The fettled casting is shown in Fig. 35.

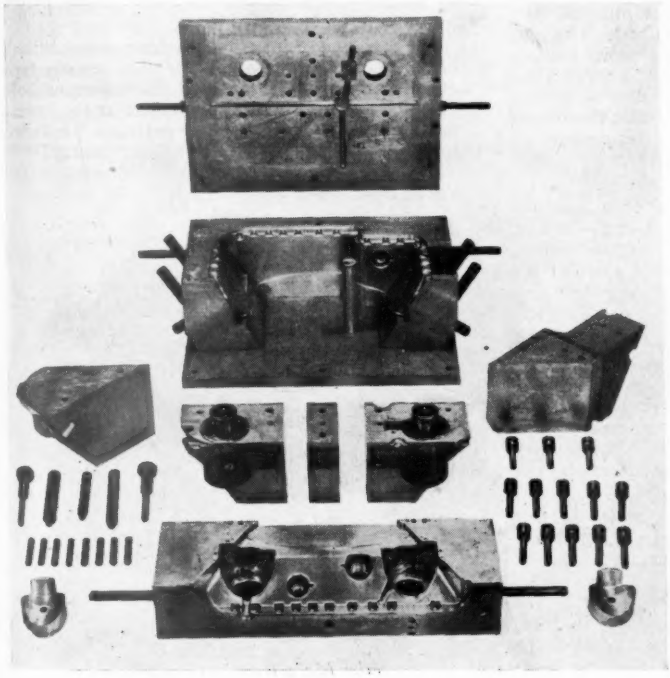


FIG. 22.—*Component Parts of the Oil-sump Die.*

PRODUCTION PROBLEMS

The many detailed problems associated with the lost-wax or investment process have been adequately dealt with by various authors in papers presented to the Institute, but the second part of this Paper attempts to list some of the more salient points

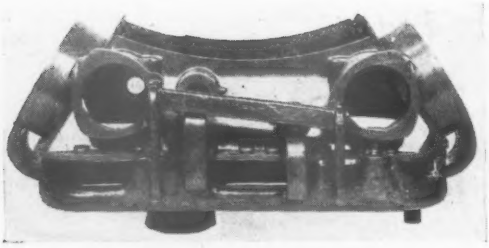


FIG. 23.—*Runners and Feeders attached to the Main Flanges of the Oil-sump Pattern.*

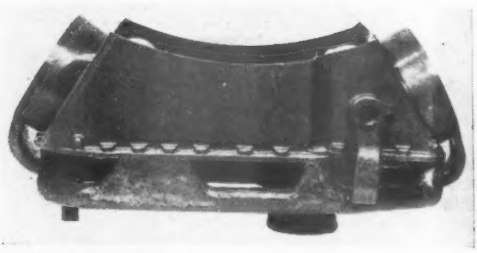


FIG. 24.—*Further View of the Wax Assembly for the Sump.*

which confront the foundryman embarking upon the investment casting process.

Injection Dies

When a new component enters the foundry, the first decision to be made is on the type of die required, *i.e.*, a cast low-melting-point metal die, or a machined metal die. The three over-riding factors when making this decision are:—(*a*) Complexity of the die—the more complex the die, the greater the need for a machined die; (*b*) the dimensional accuracy required in the resultant casting—the closer the accuracy, the greater the necessity for a machined die, and (*c*) number of castings required—invariably a small number of castings does not warrant the cost of a machined die.

The employment of machined dies is often resorted to as a general policy, especially if a metal model or pattern of the component must be produced for the alternative cast-die method. The time consumed in this operation is often more usefully spent in machining a die, except when a large number of dies is necessary, probably over a period, for a particular component, the cast dies then being produced *ad lib.* from the metal master-pattern.

The main difficulties experienced when using soft-metal dies are:—

(1) The tendency for the metal to expand on solidification. However small this expansion is, it often means a scraping and paring operation in order to produce a die-cavity to within dimensional limits.

(2) Hand-finishing operations are invariably necessary in order to impart a high-quality finish to the cavity face. This proves difficult in the restricted recessed parts of the die.

(3) The type of metal (bismuth-tin alloy series) used for cast dies has a tendency to creep under pressure thus necessitating frequent scraping and polishing in order to maintain dimensional accuracy.

(4) Being made of soft material, these dies are easily damaged and distorted and do not stand up to shop usage as satisfactorily as a steel die.

Wax-Pattern Production

The manufacture of wax patterns is a matter of prime importance and also of some controversy. The type of wax used for pattern production must have certain basic characteristics; (*a*) Good strength to withstand handling; (*b*) a degree of hardness to resist scratching; (*c*) good fluidity at temperature in order to fill the mould cavity and reproduce surface detail; (*d*) low contraction figure on solidification, and (*e*) minimum ash content.

The properties of a typical wax for pattern production are:—

Setting point in deg. C.	56
Percentage contraction, 60 deg. C. to 20 deg. C. ...	4.6
Percentage ash on ignition	0.05
Strength in gm. of a 100 by 20 by 5 mm. bar ...	2,700

The injection of wax into the die must observe certain basic fundamentals. It is not sufficient to produce a die and then, having decided that wax must be introduced into the cavity, to drill a hole in the most likely place and expect to get a perfect pattern. The position of the injection hole must have consideration during the initial stages of die design and must be related to—:

(*a*) The type of injection machine to be utilized, *i.e.*, vertical or horizontal. If the vertical type of injection machine is used the injection hole must be arranged to introduce wax at the lowest point of the cavity in order to pastulate "bottom-running" conditions and minimize turbulence. The same is true of horizontal injection but the stricture does not appear to be quite so critical.

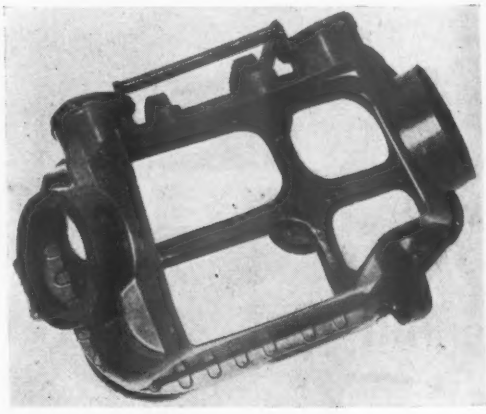


FIG. 25.—*Plan View of the Sump Pattern showing the Main Runner Channels.*

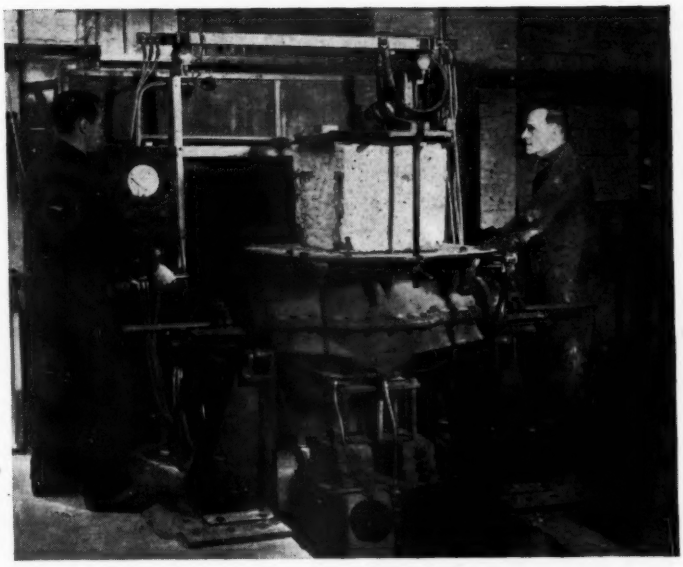


FIG. 26.—*Sump Mould Clamped in position on the Casting Furnace.*

(*b*) The size of the nozzle orifice and the cross-sectional thickness of the pattern at the point of injection. The wax sprue must be, as nearly as possible, equal in cross-sectional area to the section of pattern requiring to be fed and the injection hole must be slightly smaller in diameter than the nozzle orifice. Attention to the first point minimizes surface cavitation and to the second produces a more streamlined flow for the stream of wax.

As mentioned previously, the injection of wax into the die may be accomplished on a vertical-type or horizontal-type of machine. Both have advantages and disadvantages, but the ideal machine must observe the following operating conditions and embrace a high degree of control at all stages:—

(1) Die location; this must be positive for any given die but will vary according to the type of die being used.

(2) Die clamping; this must be positive and is a constant.

(3) Rate of opening injection nozzle; this alters with the size and complexity of the die-cavity and must be treated as a variable.

(4) Period of time the nozzle is in the "open" position; this depends on the cross-sectional thickness of the wax requiring to be fed, and also on the temperature of the wax and is therefore a variable.

(5) Rate of closing the nozzle; this is a constant.

(6) Die clamp release; this is constant.

(7) Nozzle temperature and wax temperature; these are variables but must be controlled to ± 1 deg. C.

(8) Injection pressure of wax; this must be a variable from nil to 500 lb. per sq. in.

Wax-pattern defects together with their cause and remedy are listed in Table I.

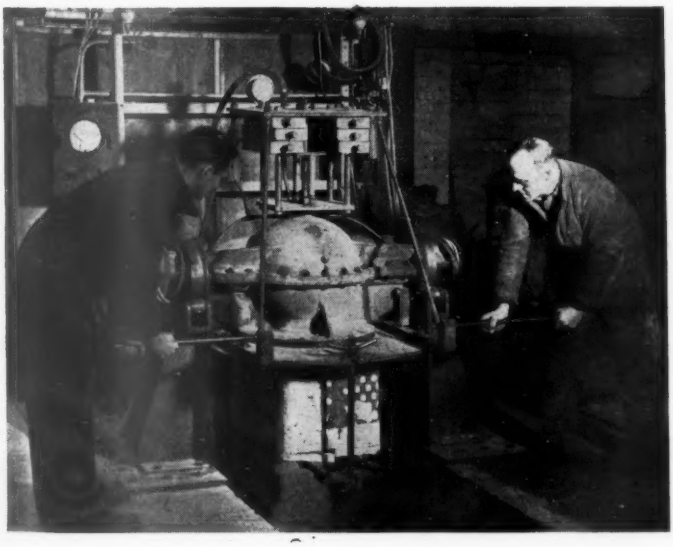


FIG. 27.—*Sump Mould Cast by Inverting the Furnace.*

Moulding and Investing

The four important factors in the moulding operation are:—(1) The primary coating; (2) the secondary investment; (3) the mould binder, and (4) the consolidation of the investment.

The investing of the wax assembly with the primary coating may be conducted by spraying or dipping techniques, many of which are covered by patents. It is the Author's experience that spraying imparts the best surface finish on castings, there being less tendency to entrapment of air-bubbles on the surface of the patterns which, if present, results in the production of a rough finish due to metal droplets adhering to the casting. The

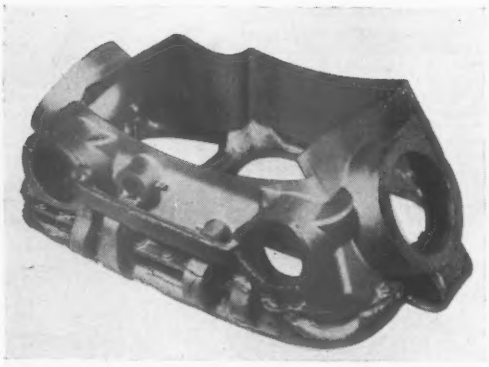


FIG. 28.—*" As-cast " Oil Sump after Shot-blasting. This casting was 20 in. long, 12 in. wide, 5½ in. high, weighed 16½ lb. and had an average wall thickness of 0.100 in.*

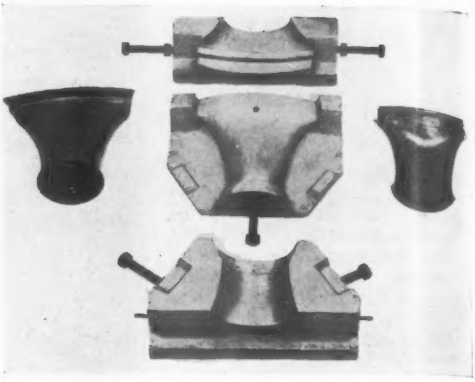


FIG. 29.—*Low-melting-point Metal Die with Wax Half-section (R.H.S.) and Completed Wax Pipe-section (L.H.S.).*

type of primary investment used also has some bearing on this problem, since one employing a spirit-base binder has less tendency to this particular defect than a mixture using water as the dilutant. It is common practice, too, to stucco the surface of the coated pattern, whilst still wet, with a coarse grade of refractory. This has a tendency to minimize the cracking of the coating as it dries, and also acts as a mechanical key for the secondary investment.

Secondary Investment

The secondary investment is best compounded from prepared alumina clays, specially graded for pressure casting to include approximately 33⅓ per cent. fine-grade (−200 mesh), 20 per cent. medium-grade (−60 +200 mesh) and 45 to 50 per cent. coarse-grade (+60 mesh), a typical sieve analysis being:—

Mesh.	Per cent.	Mesh.	Per cent.
+16	0.83	+100	8.70
+22	9.47	+150	7.35
+36	19.05	+200	4.85
+44	7.10	+300	4.23
+60	9.10	−300	28.87

Alternative Bonds

In the initial stages of development of the investment process, the secondary investment was bonded with ethyl-silicate diluted with alcohol, but this has certain industrial hazards especially when the process is placed on a production basis. Large quantities of alcohol fumes are evolved which may in the minor case lead to a fire and at the worst become an explosive mixture. It is mainly because of this, coupled with economic problems, that the past two

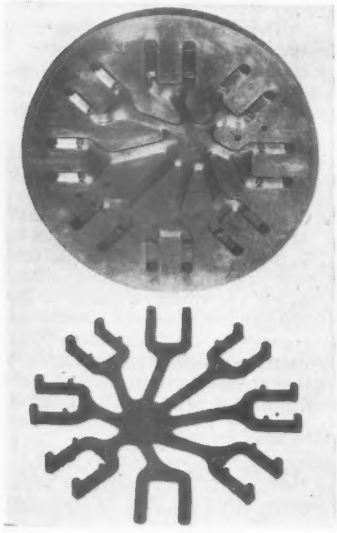
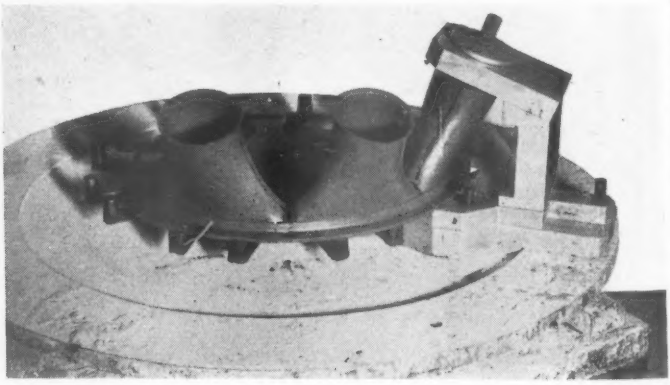


FIG. 30 (LEFT).—*Die and Wax Runner for the Entry Duct Mould Assembly.*

FIG. 31 (BELOW).—*Jig for locating correctly each Wax Section for the Entry Duct Casting.*



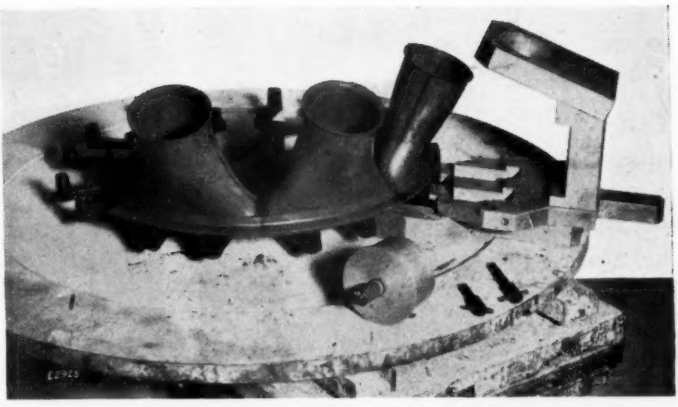


FIG. 32.—*Entry Duct Pattern Assembly — Wax Pipe Section correctly located and Jig being removed.*

years has seen the introduction of investment binders utilizing water as the diluent. Typical of these binders are silica sol, acid phosphates, sodium silicate and Portland cement. Of these materials, the greatest economic advantage is to be gained by the use of sodium silicate or Portland cement.

An important point to be taken into consideration when employing water-base binders is the method of bonding the primary coating surrounding the wax pattern. It is preferable to use a non-water-soluble binder or alternatively to use a water-soluble binder and then to water-proof the coating by means of a suitable agent, *e.g.*, dimethyl dichlorosilane[2] or tetraethyl silicate.[3] This prevents the primary coating from being softened and probably removed from the pattern during the moulding operation and thus producing a casting with poor surface finish.

Compacting

The compacting of the secondary investment around the pattern is conducted on a vibrating table, operated either mechanically, pneumatically or electrically. Mechanically-operated tables usually have a frequency of about 500 cycles per min. and an amplitude of 0.015 to 0.020 in., the main drawback being the cam wear and the frequent necessity for adjustment and maintenance to give consistent operating conditions. Pneumatically-operated tables have a frequency of 2,500 cycles per min. and an amplitude of 0.008 to 0.010 in., but again there is a certain amount of inconsistency during prolonged operation which necessitates frequent adjustment.

TABLE I.—*Wax Pattern Defects.*

Defect.	Identification.	Cause.	Remedy.
Mis-run	Incomplete pattern—radius on edge of wax of faulty area.	(1) Temperature of wax too low. (2) Insufficient velocity of wax stream as it enters the die.	(1) Increase wax temperature, or warm the die. (2) (*a*) Increase pressure of injection or rate of nozzle opening. (*b*) Utilize air vents.
Flow-lines	Series of line indentations appearing at regular intervals on the surface of the pattern.	Ditto	Ditto
Air bubbles	Clean, round holes appearing just under the surface of the pattern.	(1) Turbulence as the wax enters the die-cavity. (2) Air sucked into die on the joint line.	(1) (*a*) Arrange for streamline flow in the injection nozzle. (*b*) Ensure the injection hole is in the correct position. (*c*) Decrease injection rate. (2) Ensure die-faces and injection-hole plate are correctly seated.
Cracks	(1) Uneven-shaped cracks appearing in the radius adjoining thick and thin sections. (2) Smooth, even fracture.	(1) Variations in rate of cooling of sections of the pattern. (2) (*a*) Rapid chilling of the wax. (*b*) Pattern retained in the die too long. (*c*) Injection pressure too high.	(1) (*a*) Reduce wax injection temperature. (*b*) Ensure die temperature is correct. (2) (*a*) Warm die to correct temperature prior to injecting. (*b*) Reduce the time-period during which the pattern remains in the die. (*c*) Reduce injection pressure.
Distorted and mis-shaped	Pattern not a true reproduction of the die-cavity.	Pattern removed from the die whilst in a warm, plastic state.	(*a*) Reduce wax-injection temperature. (*b*) Increase the time-period in the die before removing the pattern. (*c*) Employ wax-chills in heavy sections.
Adhesion to die-face..	Wax pattern sticks to die-face.	(1) Surface of die insufficiently coated with die-coat material. (2) Injection pressure too high.	(1) Coat surface of die evenly and thoroughly, removing excess prior to injecting. (2) Reduce injection pressure.
Surface sinks or depressions	Depressions on flat or regular surfaces.	(1) Insufficient pressure applied during solidification of the wax. (2) Insufficient time allowed under pressure as wax is solidifying. (3) Feeding a thick section through a thin section.	(1) Increase injection pressure. (2) Increase the period during which the die is under the wax nozzle. (3) (*a*) Reduce the injection temperature of the wax. (*b*) Employ wax chills.

FIG. 33.—*Entry Duct Mould ready for Firing and Moulding-box in position for Subsequent Replacement.*

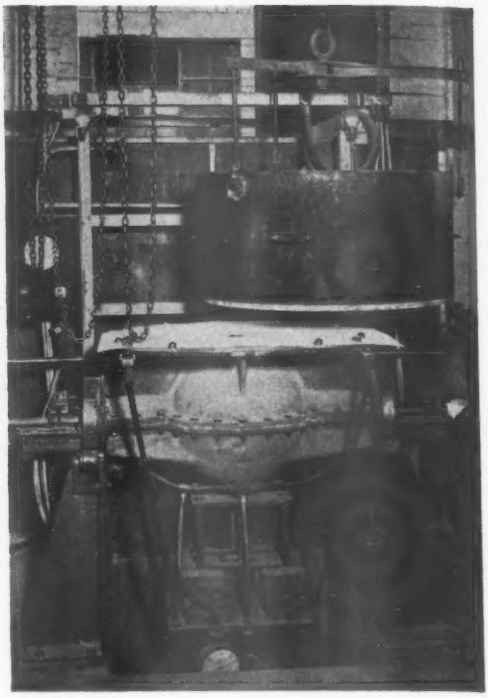


FIG. 34.—*Entry Duct Mould being placed on the Furnace ready for Casting.*

The most suitable tables are electrically operated, having a frequency of 6,000 cycles per min. and an amplitude of 0.001 to 0.002 in. Thus, the tendency, as experience has been gained, is to operate at high frequencies coupled with low amplitudes, and it is possible that higher frequencies than those mentioned would be of greater advantage, the time for compacting of the secondary investment being thus reduced to a minimum. Typical mould defects are shown in Table II.

Drying and Firing

The preliminary drying of moulds in order to disperse excess moisture or alcohol (depending upon the type of binder used) and also to melt out the wax assembly, is most satisfactorily conducted in a forced-air circulating oven, heated by gas or electricity for water-base moulds and by steam for spirit-base moulds. The drying cycle does not appear to be as critical as was at one time imagined. A set of conditions found quite satisfactory for both spirit-

TABLE II.—*Mould Defects.*

Defect.	Identification.	Cause.	Remedy.
Soft, wet mould ..	(1) Base of mould soft after vibrating. (2) Mould very weak after low-temperature drying.	(1) (*a*) Excess liquid present in the mould. (*b*) Failure of the investment to consolidate around the pattern. (2) Insufficient or non-gelation of the binder.	(1) (*a*) Adjust vibrator to correct amplitude and frequency. (*b*) Use sand of correct sieve-grading—reduce fines. (2) (*a*) Increase binder content. (*b*) Check chemistry of the process.
Mould cracks	Longitudinal or horizontal cracks in the mould, producing flash lines on the casting.	Stresses induced in the mould during the preliminary drying and wax-melt-out stage or mould firing.	(*a*) Increase percentage of coarse sand grains to investment to minimize contraction. (*b*) Reduce binder content. (*c*) Reinforce mould to counteract the wax expansion. (*d*) Re-design the running method to eliminate wax constrictions within the mould. (*e*) Ensure mould-drying and firing rates are correct.
Mould roughness ..	Surface of primary coating breaks away from mould during low-temperature drying or high-temperature firing.	Poor adhesion between primary coating and investment moulding material.	(*a*) Increase dry-strength of primary coating. (*b*) Use a coarse refractory material as the secondary coating to act as mechanical key. (*c*) Reduce the mould heating rate during the drying and firing cycle.

TABLE III.—*Casting Defects.*

Defect.	Identification.	Cause.	Remedy.
Mis-run	Incomplete filling of mould cavity.	Lack of fluidity or velocity in molten metal.	(*a*) Increase molten-metal temperature. (*b*) Increase air-pressure when pressure casting. (*c*) Increase size of ingates.
Cold-shut	Appears as a line on the casting where two streams of metal have failed to join.	Ditto	Ditto
Oxide inclusions ..	As a wrinkled skin or lap, easily lifted from casting surface.	Entrapment of oxide in stream of molten metal as it flows into mould cavity.	(*a*) Use recognized deoxidiser for alloy being melted. (*b*) Melt under reducing atmosphere. (*c*) Employ strainer-cores in the runner system.
Slag inclusions ..	Glassy in character, grey or black in colour; easily removed by chipping or shot-blasting.	Dirt and oxides forming a fluid slag on the surface of molten metal.	(*a*) Charge only clean metal into the furnace. (*b*) Use high-grade refractories for lining the furnace. (*c*) Change lining frequently. (*d*) Employ strainer-cores in runner system.
Refractory inclusions	White, grey or orange in colour, angular in shape and usually embedded in the surface of the casting.	(1) Dislodgment of particles of primary or secondary investment. (2) Pieces of furnace throat or lining.	(1) (*a*) Increase strength of investments. (*b*) Ensure moulding conditions are correct. (*c*) Handle moulds with care. (2) Throat cleaned and patched with care.
Scab	Rough, localized patch on the surface of the casting.	Primary coating becoming detached from secondary investment.	(*a*) Ensure mould drying and firing cycles correct. (*b*) Attend to vibrating and moulding conditions. (*c*) Use coarse refractory on primary coating to act as mechanical key.
Hot-tear	Crack, usually appearing at a change of section, fractured face being coloured black, brown, blue or straw.	Mould too strong and failing to yield as casting cools to room temperature.	(*a*) Decrease strength of mould by reducing amount of binder employed or the percentage fines (— 200 mesh) in the investment. (*b*) Use coring methods where possible.
Flash-lines	Excess metal on the casting appearing as thin uneven strips at right angles to the surface.	Mould cracks during drying out or firing periods.	(See under "Mould Cracks," Table II.)
Air-holes	Smooth-walled holes, usually round in shape, on the surface of the casting.	Air locked in the mould cavity and unable to escape.	(*a*) Reduce velocity of molten metal ing cavity. (*b*) Increase permeability of secondary investment.
Gas-holes	(1) Similar to air-holes, but holes more irregular in shape and surface-skin uneven. (2) Series of cavities appearing internally or externally and having a "firtree" pattern.	(1) Carbonaceous matter not removed from mould during firing operation. (2) Insufficient feed metal available as casting solidifies.	(1) Increase period of time at temperature during mould firing. (2) Increase size of feeder.

base and water-base moulds is 10 to 12 hr. at a temperature of 100 to 110 deg. C., the moulds entering the oven at room temperature and the oven reaching maximum temperature in a period of from 1 to 2 hr.

High-temperature Oven

The high-temperature-firing oven, where all residual wax and carbonaceous matter is burned from the mould, may be designed as a batch-type oven or with a moving hearth. The first type is best suited for development work, when mould sizes vary and consequently mould-firing times alter from day-to-day. For large-scale production, the moving-hearth type of oven has considerable advantages, the moulds being traversed on a set time basis as a continuous operation.

An important factor with regard to the process is the temperature of the mould at the time of casting. This should be consistent from mould to mould if castings with reproducible surface finish, freedom from shrinkage defects, etc., are to be produced. It is common practice for the high-temperature zone of the firing oven to be operated at 1,000 deg. C. and the discharge door to be situated within that zone. It is the Author's experience that a mould temperature of 850 deg. C. is adequate for the majority of components and this assists working conditions, apart from other technical advantages. It therefore becomes necessary to design mould-firing ovens with a slightly longer firing zone, burners being absent from the latter end of the zone near the discharge door and this part therefore at a lower temperature than the actual firing section (Fig. 36). This will produce standardized conditions, a sufficient time-at-temperature for the mould to be completely fired, and the casting being controlled by the metal melting-rate and not the mould-firing-rate.

Casting

The casting of metal into investment-moulds is carried out in an electric furnace of the indirect-arc or induction type, the former being the one more

FIG. 35.—*Completed Entry Duct Casting.*

universally employed. The attractive features of the arc furnace are its moderate initial cost, low running costs and slightly reducing melting atmosphere, whilst its main drawback is its tendency to give carbon pick-up on certain melts. It is usual to operate a 5 lb. capacity furnace from a 17 kva. transformer with an operating voltage of 60 and amperage 100, when the secondary reactance is at maximum input. A 10-lb. furnace requires the following operating conditions—60 to 70 v., 120 to 150 amps. Such conditions give a melting rate of 1 lb. of metal every 3 min. with a further 2 min. per lb. for superheating to casting temperature.

The casting temperature is best taken on a quick-acting indicator, operated from a Pt/Pt-Rh thermocouple enclosed in a thin silica sheath. Optical pyrometers are unsuitable, since the true temperature is masked by the presence of oxide or slag on the surface of the metal and by gases which are emitted from the carbon electrodes etc. Typical casting temperatures for various alloys are:—

Alloy	Deg. C.
Nimonic 80	1580 to 1600
Nimonic 75	1540 to 1580
H. R. Crown Max. ..	1540 to 1560
D.T.D. 49B.	1500 to 1540

The type of furnace lining or crucible also has considerable bearing on the composition of the resultant metal cast. It was soon found in the very early stages of development that siliceous-type materials were most unsuitable for furnace linings, especially for the melting of alloys of the Nimonic 80 or G.18B. type. The most suitable crucible materials for these and other alloys are alumina or magnesia, bonded with a neutral binder. Typical casting defects are shown in Table III.

Inspection and Technical Control

Mention must be made at this juncture of the desirability of adequate inspection and technical control at all stages of the process. This is of necessity more exacting with the investment process than with any other foundry technique. Adequate inspection at all stages of the process is of paramount importance, coupled with the strictest technical control, if the quality of castings produced is to be maintained on a high level. This point cannot be over-emphasized, since it is only by such methods that success is attained and maintained.

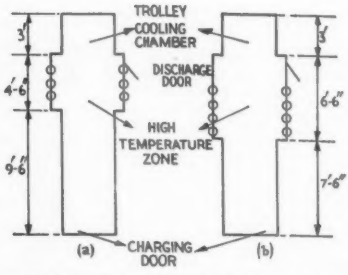


FIG. 36.—*High-temperature Firing Oven Arrangement. (a) Usual Design and (b) Modified Design.*

In conclusion, the Author wishes to express his thanks to his colleagues, without whose skill and assistance, the castings illustrated would not have been possible, and to the directors of the Bristol Aeroplane Company for permission to publish this Paper.

Notes from the Branches

Sheffield

A joint meeting of the Sheffield and district branch of the Institute of British Foundrymen with the Refractories Association, was held on March 3, in the College of Technology, Sheffield. A paper by Mr. E. J. Brown, A.I.M., was presented, entitled "Castings to Resist Abrasive Wear." Mr. Brown dealt very widely and adequately with the various metals and alloys used in castings for crushing machinery, excavators, dredgers, etc., and made a special plea for increased consideration for the use of high-chromium cast irons.

Mr. A. V. Goddard, the national president of the Refractories Association, was present and joined the discussion, asking for increased co-operation between the castings supplier and the user, particularly with regard to specifying the types of materials to be crushed. The meeting was under the chairmanship of Mr. W. J. Colton, president of the branch.

Institute of Metal Finishing

The Spring conference of the Institute of Metal Finishing (Electrodepositors' Technical Society) will be held at the Grand Hotel, Eastbourne, from April 23 to 26. A technical programme has been arranged covering both practical and research aspects of metal finishing. Subjects include the polishing of metals by mechanical and electrolytic means, metal evaporation, alloy plating, plating on aluminium, the structure of electrolytic coatings, and an open discussion on methods of combating the nickel shortage. Preprints of papers will be circulated to members prior to the conference.

Book Reviews

Case Study Data on Productivity and Factory Performance—Gray Iron Foundries. Published by the United States Department of Labor. Distributed in Great Britain by the British Institute of Management, 8, Hill Street, London, W.1. Price 20s.

This important document running to just over 100 pages contains a survey of 20 foundries lettered A to T. In general, the statistical information is given in 21 tables, so by choosing any one letter and compiling the data, it is possible to have an overall picture of any one particular plant. It is only possible to give a proper appreciation of this book by listing these tables:—(1) Unit man-hour data, by size of plant and average weight of casting; (2) number of bricks required for Whiting cupolas; (3) melting equipment statistics for selected grey-iron foundries; (4) grey-iron foundry cupola operating data, windbox pressure *versus* bed height; (5) general recommendations for operating Whiting-type cupolas; (6) approximate holding capacity of cupola well; (7) per cent. of production by core-making processes, and method in selected American grey-ironfoundries; (8) average number of different patterns used per month by plant; (9) types of patterns and per cent. used by plant; (10) per cent. of types of runners used in moulding operations by plant; (11) per cent. of machine- and hand-rammed moulds by type of machine and by plant; (12) gating and mould finishing in selected American grey-iron foundries; (13) per cent. of casting removal, by method; (14) types of operation used in cleaning and finishing castings, by plant; (15) foundry areas by department; (16) area of foundry pattern storage, and stock and yard by plant; (17) relation of output to production workers and floor space; (18) monthly production capacity and per cent. of capacity used by plant; (19) daily production, length of shift and working week by plant; (20) sands used and (21) foundry metallurgical data by plant. Amongst the "general notes" it is interesting to learn that the ratio between the production of rolled steel products and iron castings in America is 5 to 1, whilst in this country it is 4.4 to 1 which could be interpreted by saying that the efficiency of the American steel industry and the British ironfoundry industry is relatively higher in the respective countries. For machine tools, 90 per cent. of the weight is made of grey-iron castings. About one-third of America's 2,500 ironfoundries are "tied." The tables referred to earlier show that 0.5 to 2.0 man/hours are required to melt 1,000 lb. of metal; that core-making demands 2 to 10 man/hours per 1,000 lb. of good castings, whilst moulding takes up 6 to 20 man/hours on the same basis. The figures for the fettling and despatch departments vary from 1 to 11 man/hours per 1,000 lb. of castings. The yield of good castings made is of the order 65 per cent., but on a survey of 100 foundries the variation showed a range from 45 to 90 per cent. The size of the casting is the cardinal factor for the difference. There is much information given on organization, and a number of typical forms are reproduced. British readers will draw some comfort that they are not called upon to fill up the forms required by the United States Department of Labor, as they are not exactly the quintessence of simplicity. Any foundry employing 50 men or more can choose a corresponding foundry figuring in the tables and make a comparison with their own plant. Everybody who has derived benefit from the "ironfoundry" productivity report, should most certainly buy a copy of this book. It might well throw much light as to how and where the American grey-iron

(*Continued at the foot of col.* 2)

Pattern Taper

"By Chip"

Taper is desirable on all patterns to enable them to be withdrawn from the mould with ease. The amount necessary varies with the job, a deep pattern requiring more than a shallow one of the same superficial measurements. Whereas production patterns are usually well provided with taper, those for one-off jobs often only carry the minimum and thus trouble is experienced in extracting the pattern from the sand, especially if it is in any way complicated, such as many jigs and fixtures used in machine-shops.

Recently, the writer saw such a pattern, which carried a large number of loose facing pieces, etc., and which gave the moulder considerable trouble to extract from the mould due to its depth and to the fact that it carried little if any taper. To remove the pattern it was necessary to use considerable force, resulting in the pattern being extracted broken into pieces and thus being rendered unfit for the production of another casting, supposing that were required. In such cases considerable time could be saved in the foundry and a far better casting produced, if the patternmaker allowed an excess of taper on all vertical faces that were not to be machined, thus enabling the main body of the pattern to be extracted without tearing the mould or breaking-up the pattern. As, in the example cited, most of the machined faces were in the form of loose facing strips, there was no justification for the pattern being made without generous taper. It is always best for the patternmaker to err on the side of too much taper rather than too little, if good clean castings are to be expected.

House Organs

Aluminium Courier, No. 17. Issued by the Aluminium Development Association, 33, Grosvenor Street, London, W.1.

This issue contains a very interesting article on packaging. It is a subject worth investigating by the makers of light-weight commodities for distribution to multiple stores and the like.

Steel Horizons. Vol. XIV, No. 1. Issued by the Allegheny Ludlam Steel Corporation, Pittsburgh, Pa., U.S.A.

This excellently-produced house organ has on this occasion gone all "defense," and by beautiful coloured illustrations one sees quantities of aeroplanes and ships of the navy. The reviewer prefers Horizon's usual practice of dealing with peaceful industries.

Albion Works Bulletin, Vol. 6, No. 2. Issued by John Harper & Company, Limited, Willenhall.

The reviewer knows of no house organ which so satisfactorily gives continuity. In one issue there is a note about, say, breakages of castings, and in the next bulletin, one can read whether the steps taken have been worthwhile. Only too often in other house organs this continuity is lacking. Amongst interesting items in this month's bulletin is the news that this works, which ranks amongst the tidiest of foundries, salvaged last year over 100 tons of waste material.

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founding industry excels in productivity. Larger units seem to be important factors.

Good as is this book it could have been so much better by co-operation with the foundry organizations of this country. Then, of course, the statistics derived could have been more applicable to British practice. The range chosen is obviously "outsize" by our standards. V.C.F.

Steel Production in February

Steel output in February was at a lower level than that achieved in February, 1951, but production showed a considerable improvement on the previous month. Production of pig-iron, hampered by a deficiency in coke supplies, declined last month.

Figures published by the British Iron and Steel Federation show that production of steel ingots and castings last month was at an annual rate of 16,281,000 tons, compared with a rate of 16,952,000 tons in February, 1951. In January of this year production was at an annual rate of 15,234,000 tons. Pig-iron output last month was at an annual rate of 10,263,000 tons, against a rate of 10,319,000 tons in January and 9,687,000 tons in February, 1951.

Latest steel and pig-iron output figures (in tons) compare as follow with earlier returns:—

	Pig-iron.		Steel ingots and castings.	
	Weekly average.	Annual rate.	Weekly average.	Annual rate.
1952—January ..	198,500	10,319,000	293,000	15,234,000
February	197,400	10,263,000	313,100	16,281,000
1951—January ..	183,100	9,520,000	305,900	15,907,000
February	186,300	9,687,000	326,000	16,952,000

Shotts Iron Winds Up

An enterprise which has left its mark in Shotts and district—the Shotts Iron Company, Limited—is to go into voluntary liquidation. Mr. C. Augustus Carlow, in his last address as chairman at an extraordinary general meeting of the company in Edinburgh on March 5, recalled that the year 1801 saw the beginning of the iron industry in Shotts. The site for the ironworks was acquired then with a 999-years lease for a considerable area of minerals surrounding the site and containing the coal and ironstone needed in the manufacture of iron. The Company, along with the manufacture of pig-iron, always carried on business as ironfounders. Some of the products stand in Edinburgh to this day bearing the inscription "Shotts 1828"—a tribute to the quality of material and good workmanship from that early date. A booklet is to be produced summarizing the history of the Shotts Iron Company.

German Scrap Collection

It is provisionally estimated that scrap collection in Germany in January and February amounted to an average of 40,000 tons in each month. In consequence the Anglo-United States allocation for April will be increased to about 36,000 tons.

The improved collection of scrap was partly due to steelworks declaring hoardings for fear of legal action, according to the chairman of the German Scrap Merchants' Association, Herr Adloff. A draft order for the strict control of scrap recovery has been ready for signature by the Minister of Economics, Herr Erhard, since the end of January.

THREE HUNDRED EMPLOYEES of Singer Motors, Limited, have been declared redundant. An official statement issued by the management recently said that 200 workers at the Birmingham factory, and 100 at Coventry were involved. Production, which had recently reached the peak figure of 150 cars a week, would now be reduced to about 80.

Horseley Bridge's Proposed Acquisition

A proposal to acquire the outstanding 420,000 ordinary shares of Carter-Horseley (Engineers), Limited, by offering one fully paid 10s. ordinary share for every three ordinary shares of 4s. each held, has been put forward by Horseley Bridge & Thomas Piggott, Limited, constructional engineers, bridge builders, etc., of Tipton (Staffs), which already owns 180,000 ordinary shares.

Treasury consent has been obtained for the transaction, which involves the issue of 140,000 ordinary shares, so that the board proposes to increase its authorized capital from £360,000 to £810,000 by the creation of 900,000 ordinary shares of 10s. each. The offer is conditional on acceptance of 90 per cent. in nominal value of the shares to be acquired, comprising not less than three-fourths in number of such holders.

Mr. J. V. Sheffield and Mr. V. Senior, the chairman and one of the joint managing directors of Carter-Horseley (Engineers), Limited, respectively, are joining the board of Horseley Bridge & Thomas Piggott, Limited, the former as deputy-chairman and the latter as a full-time executive director.

Activities of Brush Aboe Group

The Brush Aboe group of companies announces that Aboe (Scotland), Limited, has been renamed Brush Aboe (Scotland), Limited, with registered offices at Wishaw, and will be responsible for spares and service activities of the Diesel engine factories of the group. A new company has been formed—Brush Aboe (Ireland), Limited, 195, Pearse Street, Dublin, C.5—which will shortly undertake the sales and servicing in Eire of the products of the Brush Electrical Engineering Company, Limited, and the Diesel engine factories of the group.

Following the company's reconstruction as the selling organization of the Brush Aboe group for the larger marine engine market, Associated British Oil Engines (Marine), Limited, is now operating on behalf of the marine products of J. & H. McLaren, Limited, Leeds, Mirrlees, Bickerton & Day, Limited, Stockport, National Gas & Oil Engine Company, Limited, Ashton-under-Lyne, and also the most recent company to be associated with the group, H. Widdop & Company, Limited Keighley.

Gas Team to Visit U.S.A.

A team drawn from the gas industry left on March 15 for a visit to the United States under the auspices of the Anglo-American Council on Productivity. The team will comprise personnel representing all phases of production and distribution in the industry.

Among the subjects to be studied will be the structure and organization of the American gas industry; distribution techniques; industrial and commercial applications of gas; the utilization of liquefied and gaseous products; carbonization and coke ovens; tariff systems; consumer services; industrial relations and training of personnel.

AUSTRALIA is to import steel to speed up the erection of a new aluminium production plant at Bell Bay, Tasmania. The project is under the control of the Aluminium Production Commission. In the initial stages bauxite will be imported from India.

Swarf Melting in the Cupola*

In view of the present scarcity of pig-iron and cast-iron scrap, considerable work has been carried out to conserve all cast-iron swarf by remelting in the cupola and pigging the metal. Two methods have been used, one, the more straightforward, being to charge swarf as it comes from the machine-shops, directly into the cupola. This method gives rise to a fairly high melting loss and to reduce this the second method was tried, consisting of first briquetting the swarf by mixing with cement and allowing it to harden into blocks before charging to the cupola. The detail of each of the processes is as follows:—

First Method

By the first method an endeavour is made to utilize the residual heat in the cupola after the finish of a normal day's blow, thus reducing to a minimum the amount of coke required. In the initial trials full blast (3,000 cub. ft. per min. 25 in. w.g.) was used and extremely heavy losses were found. This was caused by charging the swarf in bulk, the higher air velocity from the fans carrying the swarf up through the cupola stack. This loss was so high and so obvious that no record was kept until that trouble had been overcome. By reducing the air volume to about 1,000 cub. ft. per min. and pressure to 8 in. w.g. it was found that the coke bed was maintained incandescent and a minimum loss of swarf through the cupola stack resulted. Also by hand charging a few shovelfuls at a time the cupola was not chilled but maintained at a bright red heat until melting was completed.

Operating, cost and composition data for this method are shown in Tables I, II and III. Up to the present, it has been the custom to charge about two tons of swarf at a time, with recoveries varying from 73 to 92 per cent.; the advantage by so doing being that the whole of the metal thus melted can be collected in a two-ton ladle, thus being properly mixed and necessitating only one chemical analysis.

In the summary of results, it will be noted that 5 cwt. of cast-iron scrap has been used with each swarf melt. This scrap consists chiefly of broken core-irons and is charged to the cupola first, before the swarf addition. The effect of this is that a well of metal is obtained in the cupola hearth and any swarf which might trickle unmelted through the bed coke will dissolve in the well of metal.

The analyses shown in Table III indicate that high oxidation losses have taken place as evidenced by the reduced total carbon, manganese and silicon. Also is indicated the increase in sulphur pick-up

TABLE II.—*Cost Data for Direct Charging of Swarf at End of a Day's Blow.*

Material.	cwt.	Price per ton s.	d.	£	s.	d.	Total. £	s.	d.
Own scrap	5	250	0	3	2	6			
Cast-iron swarf	33	20	0	1	13	0			
Coke	8	136	2	2	14	6			
							7	10	0
Labour.	**hrs.**	**Rate.**		**£**	**s.**	**d.**	**Overhead. £**	**s.**	**d.**
Cupola charging ..	4	2.893		0	11	7	0	16	5
Digging and removing	10½	2.893		1	10	5	2	5	7
							5	4	0
Weight charged, 38 cwt. Produced 32 cwt. for							.. 12	14	0

Melt loss 15 per cent. Cost per ton, £7 18s. 9d.

TABLE III.—*Composition of Metal Produced by Direct Melting of Swarf. (per cent.).*

Melt.	T.C.	Si	P	Mn	S
1 ..	3.12	1.72	0.49	0.40	0.151
	3.05	1.75	0.49	0.40	0.169
2 ..	1.98	0.71	0.24	0.24	0.158
	2.42	0.66	0.24	0.24	0.163
3 ..	2.66	0.59	0.34	0.24	0.119
4 ..	3.02	0.34	0.32	0.13	0.136
5 ..	2.76	0.56	0.25	0.19	0.125
6 ..	2.50	0.44	0.28	0.15	—
7 ..	2.60	0.79	0.30	0.24	0.140
8 ..	3.02	0.91	0.31	0.39	0.125
9 ..	3.41	1.06	0.32	0.34	0.140
10 ..	3.17	0.89	0.28	0.38	0.110
11 ..	2.60	1.97	0.26	0.37	0.150
12 ..	2.92	0.70	0.29	0.32	—
13 ..	2.92	0.35	0.29	0.17	0.160
15 ..	2.82	0.89	—	0.39	0.140

* Communication from J. & E. Hall, Limited, of Dartford, Kent.

TABLE I.—*Operating Data for the First Method—Direct Charging of Swarf.*

Melt No.	Labour.	Material. Coke.	Material. Swarf.	Light C.I. scrap.	Chalk.	Metal, total charge.	Metal recovered.	Per cent. recovery.
	hrs.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	
1	14½	7¾	34	5	—	39	29	75
2	14½	8	34	5	—	39	31	79
3	14½	8	34	5	—	36	32	90
4	14½	8	34	5	—	39	32	84
5	14½	8	34	5	—	39	35	90
6	14½	8	34	5	—	39	36	92
7	14½	8	31	5	—	36	30	84
8	15	6	30	6	1	36	30	83
9	17	7	30	6	1	36	32	89
10	14½	8	36	6	1	42	35	83
11	18	8	40	6	1	46	40	87
12	20	9	40	6	1	46	42	91
13	20	12	42	6	1½	48	36	75*
14	14	10	36	6	1	42	38	91
15	14	10	30	6	1	36	32	89
Average..	14½	8	35	5.5	—	38	32	84.3

* Did not all melt.

Swarf Melting in the Cupola

caused by the additional melting. However, all these discrepancies in the analyses can be adjusted. The total carbon, on remelting, will correct itself suitably. The silicon and manganese can be taken care of by additions of ferro-manganese and ferro-silicon to the cupola charge or, at the spout. Sufficient manganese addition should be made to ensure that the sulphur is in combination as manganese sulphide thus avoiding the formation of the eutectide of iron sulphide and carbide. Allowing for these additions, it can be seen from the cost analyses that the process is still an economic proposition as well as conserving material.

Second Method

As will be seen from the figures given in Table I for the first method, the melting loss varied between 25 and 8 per cent. This was considered somewhat heavy and, with a view to reducing the loss, the swarf was mixed with Portland cement in the proportion of nine parts swarf to one part of cement. This mixing was done in a 10-cwt. capacity Winget concrete mixer and poured into rough slabs formed by the use of strips of steel plate on a paper-covered concrete floor. After 24 hours these slabs were cut to suitable handling sizes.

As in the previous method, these briquettes were charged to the cupola after the normal day's run had been completed. However, instead of operating with a "soft blast," full or normal blast pressure was continued throughout the blow. On account of the amount of slag expected, due to the Portland cement addition, the slag-hole was kept open all the time and this precaution was justified by the large volume of fluid-flowing slag which formed. It was found that the metal melted much more quickly by this method and was considerably hotter and more fluid. Table IV gives cost data and Table V the composition of the metal produced by this method.

TABLE VI.—*Cost Data for Melting Swarf by the Briquette System.*

Material.	cwt. qr. lb.	Per ton. s. d.	£ s. d.	Total £ s. d.
Core-iron, etc., scrap	5 — —	250 0	3 2 6	
Cast-iron swarf	23 — —	20 0	1 3 0	
Cement	3 — —	75 0	0 11 3	
Coke	6 3 —	136 2	2 5 11	
				7 2 8

Labour.	hr.	Rate.	£ s. d.	Overhead. £ s. d.	£ s. d.
Cupola charging	1½	2.893	0 4 4	0 6 6	
Digging and stacking	7½	2.893	1 1 8	1 12 6	
Making briquettes	11	2.682	1 9 6	2 4 3	
					6 18 9
Weight charged 28 cwt.	Produced 27 cwt. for				14 1 5

Melting loss, 3.6 per cent. Cost per ton, £10 8s. 4d.

TABLE V.—*Chemical Composition of Metal produced by the Briquetting System.*

	Per cent.		Per cent.
Total carbon	3.02	Manganese	0.39
Silicon	0.91	Sulphur	0.13
Phosphorus	0.31.		

The analysis shows a very useful product for the firm's class of casting. Considerably less oxidation has taken place by the briquetting system, with the result that the total carbon and silicon need practically no adjustment. Manganese has been lost and would have to be made up to counteract the sulphur increase.

Unfortunately the extra labour required for briquetting increases the cost per ton by almost 30 per cent. over the first method despite the fact that the melting loss has been reduced from 15 per cent. in first method to 4 per cent. by the second method.

The firm has proceeded with production as described in the first method, the reason being obvious from the cost analyses of the methods. The first is cheaper even allowing for the 15 per cent. melting loss. The cost of the extra labour involved in producing briquettes in the second more than offsets the saving in metal or reduction in melting loss.

EIGHT PANELS of industrialists and trade union representatives are to be set up by the northern regional controller for the Ministry of Supply to draw up proposals for factories on armament work to help each other with labour and materials in the event of any of them being damaged in wartime.

INTERESTED IN SECURING at competitive prices a supply of assemblies (motor, gear-box, agitator, clutch, etc.) for incorporating in electric domestic washing machine cabinets which the company intends to produce, Western Transvaal Industries & Manufacturing Company (Pty.), Limited, P.O. Box 44, Langlaagte, Johannesburg, invites United Kingdom manufacturers to send prices and descriptive details, etc., addressed "for the attention of Mr. Karan" to the above address. U.K. makers of domestic electric stoves who are looking for a local manufacturing or assembly connection are also invited to write. The Board of Trade, Commercial Relations and Exports Department, Horse Guards Avenue, London, S.W.1 (reference, CRE(IB)78487/51), should be notified of any action taken.

SHEFFIELD STEEL, engineering, and toolmaking firms will be represented at the Canadian International Trade Fair this year. A composite stand arranged in Sheffield for the National Federation of Engineers' Tool Manufacturers, and the Federation of British Hand Tool Manufacturers, will be among the exhibits. Some of the individual exhibitors will include the English Steel Corporation, Limited; Moore & Wright (Sheffield), Limited, and John Bedford & Sons, Limited.

THE QUASI-ARC COMPANY LIMITED, Bilston (Staffs), has announced that as from April 1, sales and service of Unionmelt automatic welding plant, powder, and wire will be transferred to its associated company, Fusarc, Limited, Team Valley, Gateshead-upon-Tyne. Fusarc, Limited, will continue to supply complete mechanized welding installations, as well as automatic welding heads embodying either the Fusarc continuous covered electrode system, or the Unionmelt submerged arc system of automatic welding. Skilled welding personnel are being transferred from the Quasi-Arc Company to Fusarc, and users of the Unionmelt process can be assured of full continuity in service and supplies.

Fuel Research Board's Activities

A report issued by the Fuel Research Board covering the period April 1, 1949, to December 31, 1950, paves the way for the resumption of the pre-war practice of presenting reports annually. The board's previous report was for the period 1946-49 and dealt largely with the transition from short-term wartime researches to post-war reconstruction projects.

During the 21 months covered by the latest report some increase in the accommodation and facilities at the Fuel Research Station was effected by the erection of temporary laboratories and the rearrangement of existing buildings, but the difficulties in recruiting staff and obtaining equipment have by no means been overcome. The main effort has been concentrated on the more efficient use of fuel, and investigations having this object have yielded results which, to a growing extent, are being applied successfully in industry.

Work on the elimination of smoke from hand-fired boilers has been extended to show that the reduction in smoke is accompanied by an increase of efficiency of up to 10 per cent. Since at least 20,000,000 tons of coal are burnt annually in Great Britain, a saving of 5 to 10 per cent. would be a valuable contribution to our fuel economy. The Fuel Research Station smoke-eliminator doors, manufactured by a number of firms, have already been installed on some hundreds of boilers, and efforts are continually being made to extend their use.

The introduction of improved domestic appliances for burning solid fuels to give both economy in fuel consumption and increased comfort in the home has been under active consideration during the period under review. The testing of stoves and grates designed to burn solid fuel with higher efficiency has been continued both at the Fuel Research Station and at the Scottish Branch Station at Thorntonhall, near Glasgow. Appliances that pass the specified tests are included in the "List of Improved Solid-fuel Appliances" which is circulated to local authorities and others concerned with housing. This list, together with a list of rather more elaborate models, is included in a list of "Recommended Domestic Solid-fuel Appliances" which is made available to inquirers by the Coal Utilisation Council.

With the object of conserving as far as possible the reserves of the first-grade coking coal, of which there is a particular shortage, large-scale experiments have been put in hand, in collaboration with the National Coal Board, to examine the possibilities of producing satisfactory metallurgical coke by carbonizing blends of this first-grade coking coal with other more plentiful coals. Experiments have been continued on the gasification of fine low-grade coals and cokes in order to provide producer-gas, water-gas, and gas for the synthesis of oil. Applications of the "fluidized-solids" and "suspension" techniques have been studied. An investigation is in progress at the Fuel Research Station on the combustion of coal to provide the energy for gas turbines.

Methods for the removal of sulphur compounds from flue gases, particularly in relation to the gases emitted from electricity generating stations, have been studied at the Fuel Research Station for some time, and, more recently, attention has been directed to a process in which ammoniacal liquor is used and sulphur is recovered, mainly in the form of ammonium sulphate. Promising results obtained in a small pilot plant have led to the decision to erect at the station a larger plant to deal with 25,000 cub. ft. of flue gas per hr. Investigations of the synthesis of oils from coal by the Fischer-Tropsch process and its modifications have been continued, and the construction of a pilot plant to produce 30 to 50 galls. of product a day has been started.

Board Changes

STEEL COMPANY OF WALES, LIMITED—Mr. L. J. Davies has retired from the board.

SADLER & COMPANY, LIMITED—Major S. G. Coulson has been appointed a director.

BUTTERLEY COMPANY, LIMITED—Mr. W. P. Mellen has been appointed a director.

ROUND OAK STEEL WORKS, LIMITED—Mr. G. R. Ward has resigned his directorship.

W. & T. AVERY, LIMITED—Mr. Kenneth Preston has been appointed a director as from April 1.

GOODLASS WALL & LEAD INDUSTRIES, LIMITED—Mr. E. P. Reynolds has retired from the board.

HILLS (WEST BROMWICH), LIMITED—Mr. A. Lamond has been appointed deputy managing director.

RANSOME & MARLES BEARING COMPANY, LIMITED—Mr. E. Belcher and Mr. J. B. Samson have been elected directors.

SCOTTISH AGRICULTURAL INDUSTRIES, LIMITED—Mr. S. W. Cheveley and Mr. W. Donald Scott have been appointed to the board.

CRAVENS RAILWAY CARRIAGE & WAGON COMPANY, LIMITED—Mr. E. Allsop and Mr. E. T. White have been appointed directors.

CROSTHWAITE FURNACES & SCRIVEN MACHINE TOOLS, LIMITED—Mr. J. W. Blakey, who has been manager of the company's London office for a number of years, has been appointed a director.

ALEXANDER FERGUSSON & COMPANY, LIMITED—Mr. E. P. Reynolds, a director since 1935 and chairman for the past eight years, has resigned from the board. Mr. Colin F. Kenmure, managing director, has been appointed chairman.

Keighley Employer Awarded Damages

At Keighley County Court, last week, Mr. Harry Matthews, trading as H. Matthews and Company, mangle manufacturers, Greengate Works, Keighley, was awarded £5 17s. damages, with costs, against an employee, Arthur Rhodes, foundry labourer, of 4, Denby Road, Keighley, for breach of a verbal agreement. It was stated by Rhodes that he had been promised overtime work, and left last December when he was told his overtime would be stopped. The Registrar, Mr. G. S. Charlesworth, stating that he would welcome an appeal against his judgment, said he was very sorry to give judgment against Rhodes, who, he said, had worked overtime to an extent which was "laudable and most unusual." It was obvious, however, that no employer could guarantee overtime, and Rhodes had no just cause for leaving. Mr. H. Hodgson, secretary of the Keighley branch, Amalgamated Union of Foundryworkers, stated afterwards he would await advice from headquarters on the question of an appeal.

Glacier Metal Company's Acquisition

The Glacier Metal Company, Limited, Alperton, Middlesex, has acquired, as from December 31, 1951, the capital of Scottish Precision Castings, Limited, Hillington Estate, Glasgow, manufacturers of aluminium and brass die-castings. Scottish Precision Castings, Limited, will retain its own name and identity, although its products will be sold in all markets at home and overseas through the Glacier commercial and sales organization, which organization is, in fact, already in contact with the main markets of Scottish Precision Castings, Limited. Both companies already have many customers in common.

Personal

MR. BOB KENNEDY, for many years the popular secretary of the American Foundrymen's Society, has been appointed assistant professor at the University of Illinois.

GENERAL DONALD ARMSTRONG, president of the United States Pipe and Foundry Company, Burlington, N.J., has resigned to accept a post abroad in connection with economic mobilization in Europe.

LADY LITHGOW has been appointed chairman of Lithgows, Limited, shipbuilders, Port Glasgow. Sir John M. Duncanson will continue as deputy chairman. Mr. Jackson Millar has been appointed a director.

MR. E. WHARTON, chief chemist of the Staveley Iron & Chemical Company, Limited, spoke on "Foundry Sands" at the Chesterfield Technical College recently. Mr. E. Williams, general manager of the Markham Engineering Company, was chairman.

MR. W. A. MAIR, director of the Fluid Motion Laboratory at Manchester University has been elected to the Francis Mond Professorship of Aeronautical Engineering at Cambridge from October 1, in succession to SIR MELVILL JONES who has occupied the professorship since it was founded in 1919.

THE FOLLOWING MEMBERS of the Institute of British Foundrymen have been elected directors of Federated Foundries, Limited:—John Cameron, junr., James Jackson, R. S. M. Jeffrey, B.Sc., F.R.I.C., and J. J. St. Clair. All these members are associated with the Scottish branch, Mr. Jeffrey being a past-president of the branch.

MR. HARRY P. RADFORD, a past president of the East Midlands branch of the Institute of British Foundrymen, on March 6 last completed 50 years of service with S. Russell & Sons Limited, Bath Lane, Leicester. He was originally engaged as a junior in the office and has for many years been the senior foundry clerk. The Directors recognized his loyal and devoted service over this long period of years by presenting him with a silver coffee set and silver tray. Mr. Radford is still remaining in the employment of the Company and the directors hope to have him with them for many years ahead.

VICE-ADMIRAL ERIC LONGLEY-COOK, who retired last September after 40 years in the Royal Navy, has been appointed managing director of the Fairfield Shipbuilding & Engineering Company, Limited, Glasgow. He was recently a director of Naval Intelligence and in earlier years specialized in gunnery. He gained the C.B.E. for his part in the Sicily invasion during the war and was mentioned twice in dispatches following the Normandy landings and in the relief of Greece. Later he gained the D.S.O. in the South of France invasion. In the 1950 New Year Honours he was made a C.B. and given the rank of Vice-Admiral four months later.

MAJOR E. PECKHAM, managing director of Metalock (Great Britain), Limited, recently returned to Britain by B.O.A.C. Stratocruiser from New York after a round-the-world business tour by air. In Calcutta and Sydney, Major Peckham found business prospects so promising that he cabled his head office for staff to be sent to each place. He also arranged for a new Metalock Company to be formed in Calcutta; and he held discussions about another new company which has just been formed in Auckland. Metalock is a cold repair system for iron castings which replaces welding. It originated in Canada some eight or nine years ago and was brought to this country four years ago by Major Peckham.

Obituary

MR. JAMES ROY ANDERSON, late cashier of Springfield Steel Company, Limited, Glasgow, died on March 2.

MR. W. H. PILMOUR, managing director and secretary of Parsons Marine Steam Turbine Company, Limited, Wallsend (Northumberland), died on March 7 at the age of 75. He had been with the company since 1898.

THE AMERICAN PRESS reports the death of MR. R. F. HARRINGTON, who was for many years foundry manager with the Huntspiller Manufacturing Corporation. He acquired an international reputation as an authority on moulding sand testing.

THE DEATH occurred on March 12 of MR. JAMES CROWTHER at his home, Willow Dene, 393, Bradford Road, Gomersal, near Leeds, at the age of 75. He was managing director of Henry Crowther and Sons, Limited, pulleys, shafting and rolling mills, of Cleckheaton, near Bradford, which firm was founded by his father.

MR. CHARLES D. HANNA, chief draughtsman of Andrew Barclay, Sons & Company, Limited, locomotive builders, of Kilmarnock, since 1939, has died at the age of 66. He served his apprenticeship with the North British Locomotive Company, Limited, and later took up the post of assistant chief draughtsman with Wm. Beardmore & Company, Limited, Dalmuir. In 1938 he went to Crompton Parkinson, Limited, Chelmsford, as mechanical adviser on Diesel-electric engines.

MR. CYRIL C. COVINGTON died last Saturday, aged 56. Previously with Atlantis Engineering Company, Limited, of Lewisham, he started Reliance Foundry (Norwood), Limited, in 1934. He was also a partner in H. O. Beere & Company, of Peckham, a director of Ancaster Foundry, Limited, Sydenham, and managing director of General Engine & Boiler Company, Limited, of New Cross. Well-known amongst London founders, he will be particularly remembered for the helpful services rendered to the smaller non-ferrous shops. His son Geoffrey will continue his business connections.

SIX YEARS to the day after retiring from his position as secretary of the Institute of Fuel, MR. PHILIP CROSBY POPE died suddenly recently. On his retirement he was made an honorary member of the institute, becoming one of the very few on whom that distinction has been conferred. Born on January 26, 1872, Mr. Pope served an early apprenticeship with Richard Hornsby & Sons, Grantham, and also with Laird Bros., Birkenhead. His first appointments were with the British Westinghouse Company and the Lancashire Power Company, and early in this century he became the agent in Manchester for Siemens Bros. & Company, Limited.

THE GREEK AUTHORITIES have announced that stocks of ferrous scrap are sufficient to meet all obligations to despatch it to Italy against deliveries of finished goods as reparations, and to supply the local industry for 18 months.

FOR THE FOURTH successive year Samuel Fox & Company, Limited, branch of the United Steel Companies, have organised a Fuel Efficiency Exhibition during this week. The emphasis this year will be on Fuels of the Future, and the Company has been fortunate in obtaining the assistance of the Ministry of Supply. Among the interesting exhibits from the Department of Atomic Energy is the model of "Gleep" from the Science Museum, London. Other industrial firms are also supplying equipment and exhibits.

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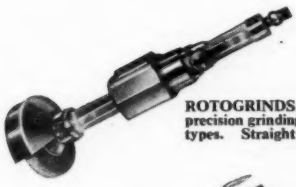

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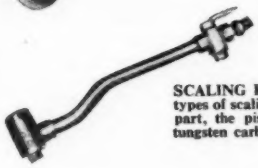

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SUBSIDIARY COMPANIES, BRANCHES AND AGENCIES THROUGHOUT THE WORLD. HB34

News in Brief

TWO THOUSAND TONS of Japanese steel, to be used in making wire rope, were unloaded at Glasgow last week.

UNDER A NEW TRADE AGREEMENT Italy is to export rice, hemp, and sulphur to Belgium and Luxemburg in return for coal, copper, and iron.

FIFTEEN VETERANS, whose length of service with W. G. Bagnall, Limited, locomotive and railway wagon builders, of Stafford, totalled 679 years, received awards from Mr. W. A. Smyth, managing director, recently.

LOBNITZ & COMPANY, LIMITED, are to build a twin-screw oil-fired sludge vessel of 1,500 tons for London County Council. Tender amounted to £272,750 and the Admiralty have issued the licence for the construction of the vessel.

INCREASED CHARGES FOR GAS, which came into effect on Monday, will cost industrial firms in Sheffield and Rotherham at least £150,000 a year. Firms in the district use nearly three-quarters of all gas sold by the East Midlands Gas Board for industrial purposes.

HURST NELSON & COMPANY, LIMITED, rolling-stock builders, etc., of Motherwell, have received orders from the East African Railways for 184 large covered wagons, and from the Rhodesian Railways for 30 bogey tank-wagons. Deliveries are expected to be made in 1953.

A CONTRACT for the construction of two concrete dams and four miles of tunnelling at Glen Morison (Inverness) has been placed with Mitchell Engineering Limited, Peterborough, by the North of Scotland Hydro-Electric Board. The contract is valued at about £4,500,000.

AT A MASS MEETING last week, 700 steel workers at Port Talbot passed a resolution pledging themselves to take all measures possible to prevent the Steel Company of Wales, Limited, from closing down four production departments of the Port Talbot works at the end of June.

ALL THE VACANCIES available for the fourth foremen's training course organized by the Institute of British Foundrymen, to be held at Ashorne Hill, near Leamington Spa, from Thursday, April 3, to Saturday, April 5, 1952, have been taken up and, as there is a waiting list, no further applications can be entertained.

TO ASSIST SIGN-WRITERS working in its factories, I.C.I. Paints Division has issued a leaflet which recommends and reproduces the gill sans bold alphabet for the painting of directional and safety signs. Any factory manager interested may obtain a copy of the leaflet from the Public Relations Officer, I.C.I. Paints Division, Slough.

MR. F. CHRISTEN of P.O. Box 2231, Zurich 23, Switzerland, in a private letter to the Editor says that there exists in the United States a hydraulic briquetting press capable of producing grey-iron briquettes having a density up to 80 per cent. using swarf as a raw material. He is supplying to a local firm one capable of turning out 2 tons of briquettes per hour.

CALEDON SHIPBUILDING & ENGINEERING COMPANY, LIMITED, Dundee, are to build a passenger-cargo motor vessel for the Sarawak Steamship Company, Limited, Kuching, Sarawak. The largest vessel in the present Sarawak fleet is the Rajah Brooke, which was built by the Caledon company three years ago. Latest order is the sixth for the Company in a week.

A NEW EXTENSION of about 20,000 sq. ft. has been made to the premises of E. W. Bliss (England), Limited, in Alfreton Road, Derby. This will supplement the production of power presses, already being manufactured at their City Road Works, Derby. At present they have an order from Italy which amounts to £150,000. It is hoped that production at the new works will begin in May.

GLASGOW is to have a share in a contract which has been placed by the Ministry of Fuel and Power for a prototype open-cycle, coal-burning gas-turbine locomotive. Details of the placing of the contract were given last week-end by the North British Locomotive Company, Limited, Glasgow. They are to construct the chassis for the new locomotive while the external-combustion gas turbine is to be supplied by C. A. Parsons & Company, Limited, Newcastle-upon-Tyne.

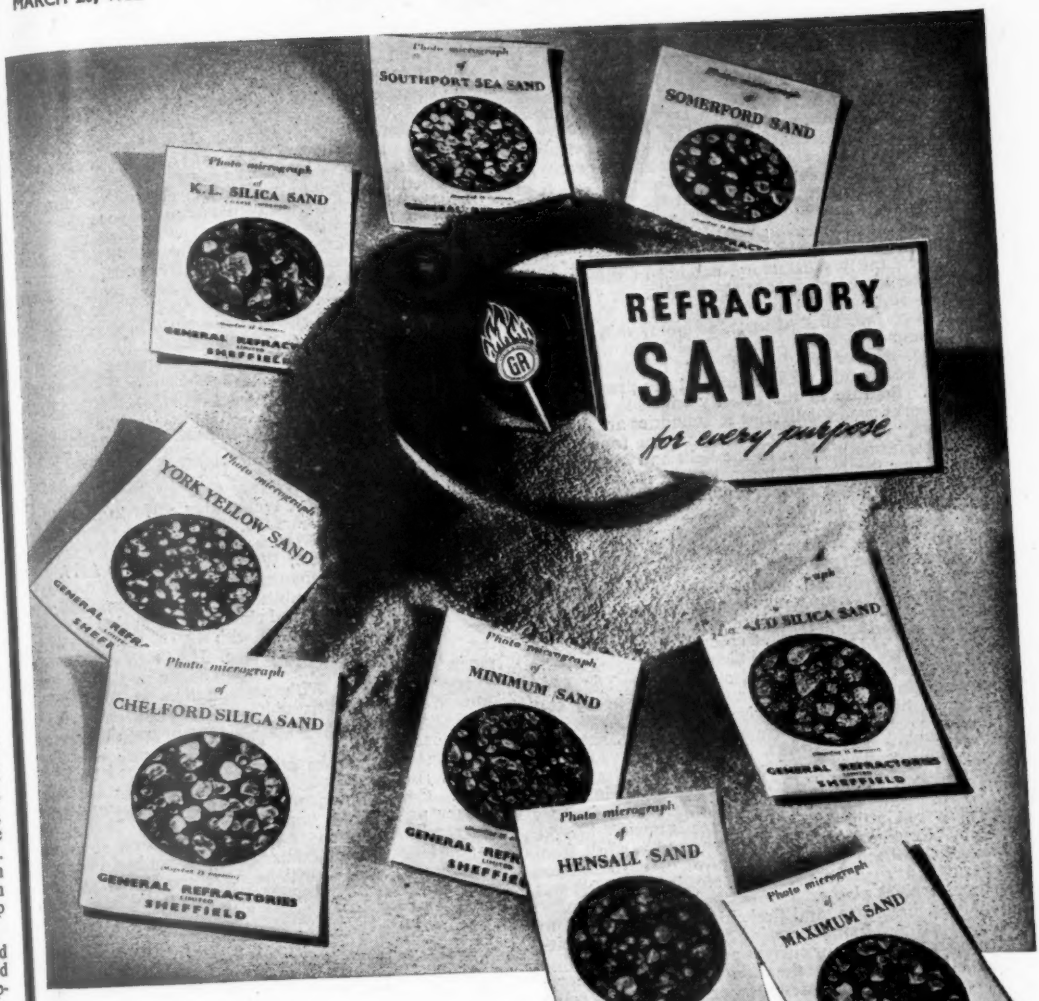
BRITISH RAILWAYS had won the winter freight battle, said Mr. John Elliot, chairman of the Railway Executive, addressing the Rotary Club of London last Wednesday. He gave a warning, however, of the effect of steel rationing on the railways. With fewer wagons and fewer locomotives in stock than in 1948, and with a reduced staff, British Railways had carried more traffic this winter than in any winter since unification, while the distance each ton of freight had been hauled was the highest on record.

THE LIMITATION of exports of fabricated steelwork would do irreparable harm to the steel industry's standing in overseas markets, said Sir Ellis Hunter, president of the British Iron and Steel Federation, in Edinburgh, recently. Sir Ellis was addressing the annual meeting of Redpath, Brown & Company, Limited, of which he is chairman. The Government allocation scheme, he continued, which precluded the issue of export licences before late 1953, was a short-term policy occasioned by urgent economic problems, and it ought not to be allowed to obscure the long view.

BRITAIN'S LARGEST TROOPSHIP, the 21,833-ton Empress of Australia, bought by the British Iron & Steel Corporation to provide scrap for the U.K.'s steel production drive, may come to the Clyde for breaking-up. The Empress of Australia, which has been managed since the war by the Canadian Pacific Steamships, Limited, on behalf of the Minister of Transport, is due back from Korea and Malaya with troops on May 1. Many foreign firms, it is understood, were interested in the vessel, but in view of the acute shortage of steel in Britain, the owners decided to sell her for breaking-up in this country.

A MASS WALK-OUT from nearly every engineering and shipbuilding establishment on the Clyde was staged last week by over 2,000 engineering apprentices in support of their claim for a £1 a week pay increase. At a meeting held in Glasgow later in the day, a large majority voted to continue the strike. Employees of about 28 companies are believed to be involved. The district committee of the Confederation of Shipbuilding and Engineering Unions is offering no financial support, and the apprentices have been warned that a claim to provide for a nation-wide increase, coming up for consideration in the near future, might be jeopardized by their action.

LORD JUSTICE SINGLETON dismissed the appeal brought by E. W. Wynn (Ironfounders), Limited, of Cherry Street, Birmingham, on March 12 against the judgment given by Mr. Justice Streatfield at Birmingham Assizes, in the case of an injured employee. Mr. Justice Streatfield had awarded £4,222 damages to Mr. John Edward Acton (36), a foundry labourer employed by the appellants, whose left arm was severely injured by a hot casting in July, 1949. It was announced in the Court of Appeal that although the appeal would be dismissed, the damages would be reduced by consent to £3,222 and E. W. Wynn (Ironfounders), Limited, would pay the costs of the appeal.



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Raw Material Markets

Iron and Steel

The need for an increased production of pig-iron daily becomes more evident. The steelworks, whose supply of scrap is considerably below the tonnage required to enable them to produce to capacity, are clamouring for larger supplies of pig-iron, which producers are unable to satisfy, and at the same time meet the demands made by the foundries. Pig-iron production from the furnaces in blast is generally satisfactory. Supplies of ore appear to be adequate, and coke deliveries are fairly satisfactory, but not of sufficient bulk to provide the extra quantities required for fresh units.

Given supplies of raw materials, there are furnaces ready to go into blast at once, assuming that the necessary labour can be found. Until more units are in operation, neither steelworks nor foundries can be supplied adequately with pig-iron at the present rate of demand. Because of the priority which is being given to steelworks needs, deliveries to foundries are restricted, particularly of hematite to the engineering foundries and high-phosphorus pig-iron to the light and jobbing foundries. After local needs are met there is little hematite left for distributing further afield, and the supply of high-phosphorus iron to the foundries is reduced because furnaces have been changed over to the making of basic pig-iron for steel production.

Meanwhile, the foundries are well provided with work, and could use larger quantities of pig-iron than are forthcoming. With no reserves of iron, they are dependent entirely on current supplies, and any interruption to deliveries interferes with production. The foundries are also experiencing continued difficulty in obtaining sufficient supplies of cast-iron and steel scrap. There is a heavy demand for machinery and ordinary heavy cast-iron scrap, but few parcels arise.

Foundry coke deliveries are made regularly, but many foundries have short stocks, due chiefly to reductions in their allocations to provide increased supplies for the blast furnaces. The price of foundry coke was increased by 3s. 4d. per ton as from March 7. Durham foundry coke delivered in the Birmingham area is now £6 17s. 5d. per ton. A reduction of 2s. 2d. per ton with effect from March 7 has been made in the price of hard furnace coke supplied from the Yorkshire, Nottinghamshire, and Derbyshire NCB plants.

Ganister, limestone, and firebricks can be secured to requirements and foundries using ferro-alloys are receiving sufficient supplies for current needs.

Short-time working is the rule for most of the re-rollers, and, due to the present shortage of steel, some of the mills at the steelworks are also either closed or working a reduced number of shifts. There is, therefore, little prospect of home steelworks sending increased tonnages of semi-manufactured steel to the re-rollers, and although there has been some improvement in deliveries from the Continent, many of the re-rollers have not shared in these supplies. Work can only be programmed on a day-to-day basis as consignments of steel come to hand.

Heavy demands are made for small sections, bars, and strip. Shortage of sheets is causing much difficulty to consumers, who in some instances are forced to curtail operations, but the mills cannot improve on present outputs until larger deliveries of sheet bars are obtained.

Non-ferrous Metals

Tin is again a quiet market and price changes last week did not amount to much, even though the quotation on the Singapore market fluctuated rather wildly. It has been reported that the talks between the Reconstruction Finance Corporation and the Bolivians are likely to start again at any time. Contrary to expectations, no settlement was reached in the negotiations at Washington between the R.F.C. and the representatives of the Indonesian producers. Had the latter been prepared to settle on the basis of $1.18, the matter would doubtless by now have been arranged, but the last news received was that Indonesia was holding out for $1.25, and this price the Americans are not disposed to pay.

Consumption in the U.K. during January was the highest for a long time past, reaching 2,287 tons, an advance of more than 500 on December. Stocks in consumers' hands rose slightly to 1,784 tons. Recently, however, there was a fall of something like 2,000 tons in Metal Exchange stocks, believed to be connected with the Government's sale of 20,000 tons of tin to the U.S.A. Conjecture has been rife on the subject of how much tin has already been shipped to America in fulfilment of the British Government's obligation, but no figures have been reported.

London Metal Exchange official tin quotations were as follow:—

Cash—Thursday, £977 10s. to £979; Friday, £976 10s. to £977; Monday, £975 to £975 10s.; Tuesday, £977 to £977 10s.; Wednesday, £974 to £975 10s.

Three Months—Thursday, £977 10s. to £979; Friday, £976 10s. to £977; Monday, £975 10s. to £976; Tuesday, £977 to £977 10s.; Wednesday, £976 to £977.

Apart from tin figures, the Bureau of Non-ferrous Metal Statistics has published the January statistics relating to copper, lead, and zinc. Consumption of copper was 52,809 tons, compared with 43,936 tons in December. Of the January tonnage, 31,613 tons comprised virgin copper and 21,196 tons copper and alloy scrap (copper content). With consumption at such a high rate, it is not surprising that stocks declined, and at 106,890 tons were about 6,500 tons below the figure at December 31.

Lead stocks, on the other hand, advanced to 89,831 tons, a rise of about 12,600 tons over the December figure. Consumption of lead, virgin and secondary, in January was 27,986 tons, compared with 22,619 tons. Zinc stocks rose from 39,659 tons at the end of December to 44,539 tons at January 31. Consumption of zinc in December was, it will be remembered, 24,322 tons, virgin and secondary. The January total was 26,206 tons.

Lead Costs Less

The price of lead to United Kingdom consumers was reduced on Tuesday by £7 to £163 a ton. An announcement by the Ministry of Materials said that the reduction was made possible by lower prices negotiated with Commonwealth producers.

The Ministry also announced the removal of all restrictions on the amount of lead which may be purchased for consumption.

DURING the nine months ended December, 1951, 45 experts, including 15 from the United Kingdom, were made available for India, Pakistan, and Ceylon under the technical co-operation scheme of the Colombo Plan. In the same period, facilities were provided for 330 trainees from South and South-East Asia.

SEVERAL LONG-SERVICE EMPLOYEES of the Renishaw Iron Company, Limited, near Sheffield, were presented with either a cheque or a gold watch at a recent ceremony. The presentations were made by Mr. J. F. Stanier, chairman and managing director, and Dr. J. H. W. Laverick, a director and former chairman, who has been on the board since 1917.